Marconi
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6-WIRE MEASUREMENT KIT

Instruction Manual

MP MASTER
MA23341

EQUIPMENT 1968

TITLE ..... 6-WIRE MEASUREMENT KIT

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DOCUMENTS ..... None

MANUAL CHANGE

This change note corrects errors and omissions detected in the manual since it was published. Please correct the manual in line with the following information.

Chap. 5, Page 3, Para. 7, line 7

Amend resistor value from 100 Ω to 250 Ω

Chap. 7, Page 7, Fig. 4

Delete the annotations "A", "B", "C3" and "C2" from the lower edge of the p.c.b. boundary (shown chain dotted).

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Instruction Manual

H 51968-900G

6-WIRE MEASUREMENT KIT

Type 1968

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NOTES AND CAUTIONS

This equipment is provided as an upgrade to an in-circuit a.t.e. system. The notes and cautions applicable to that system are valid for this upgrade and due care should be taken.

Note ...

Each page bears the date of the original issue or the code number and date of the latest amendment (Am. 1, Am. 2 etc.). New or amended material of technical importance introduced by the latest amendment is indicated by triangles positioned thus ▶ ..... ◀ to show the extent of the change. When a chapter is reissued the triangles do not appear.

Any changes subsequent to the latest amendment state of the manual are included on inserted sheets coded C1, C2 etc.

Chapter 1

INTRODUCTION

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INTRODUCTION

1. The 1968 6-Wire Measurement Kit is intended to be fitted to the Marconi Instruments System 80 series In-circuit a.t.e. systems, and provides that system with improved resistance and inductance measuring capabilities. Actual measurement of resistors is still made using the standard hardware but the guarding performance is enhanced. Inductance measurements in the range 1 to 30 μH with a 25% overrange capability, are possible using a special circuit.

Resistance measurements

2. The 1968 Kit allows the following forms of d.c. resistance measurements to be made (in addition to the standard 2,3 and 4-wire measurements):

(a) 5-wire measurements

(b) 6-wire measurements

(c) Active guard 3-wire measurements

(d) External measurements : 5-wire
: 6-wire
: 5/6 wire

3. Chap. 3 gives a brief explanation of how existing d.c. resistance measurements are made and proceeds from this to give a comprehensive description of how they are achieved with the 1968.

Inductance measurement

4. The low inductance measurement circuit utilizes the standard switching matrix to apply a 102.4 kHz signal, derived from the AM5 Admittance Meter source board to the unknown inductor. The effect of this is monitored via the special circuit which passes the result to the ADC for measurement, again via the standard matrix routes.

HARDWARE

5. The 6-wire Measurement Kit contains a measurement board, AM22, and cables to connect it into the system. The board is designed to fit into one of the spare slots in the AM9 Motherboard in the measuring frame. The cables replace existing cables and allow the AM22 to be connected into the C pole wiring between two of the analogue switching sub-units. Details on the installation of the kit are given in Chap. 2.

6. The AM22 can be installed at system build time in any of the current range of System 80 series in-circuit a.t.e. systems, and can also be fitted retrospectively in most of the existing System 80 series. However, the following restrictions apply:

(1) At least 272 analogue test points must be present and it is recommended that at least 384 analogue test points are available. This means that you must have at least two analogue sub-units with the second one at least partially filled with test point cards.

(2) The AM5 Admittance Meter source board must be at build state 6 or later. Systems built after November 1985 will have this board as a matter of course but previously installed systems may not. In the latter case you are advised to consult with your local Marconi Instruments agent for the best course of action (i.e. modify the existing board or fit a new admittance meter pair).

(3) Installation cannot be made in a system in which spare slots S1 and S2 in the 1838 Measuring Frame are both occupied. This can happen, for example in a System with extra AM8A or AM8B boards for controlling extra power supplies and/or with AM18 or AM18/1 Instrumentation Interface boards, etc.

7. In addition to the actual 1968 hardware, special versions of the self check unit, and associated programs, are available to test a system with the kit fitted.

SPECIFICATION

8. This section provides some specification details on the 6-wire measurement kit, when in use. To do this, for resistance measurements, it is necessary to define adjacent resistances: Fig. 1 illustrates the conventions used. Note that to achieve the specification quoted a warm-up time of 30 mins (nominal) is required.

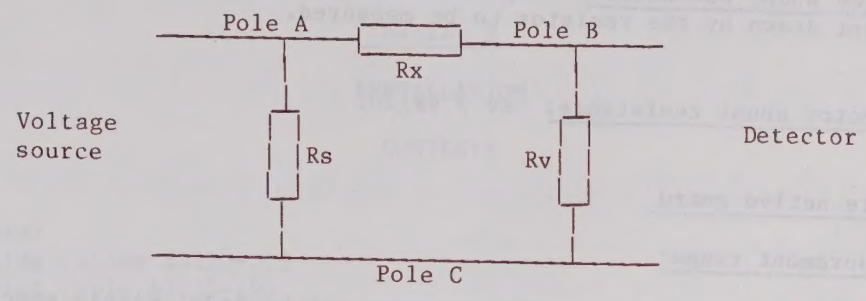

Fig. 1 Resistance definitions

Description

9. **Six-wire measurement:** Normal 4-wire measurement with active guard applied.

10. **Three-wire active guard:** An operational amplifier is used to sense the voltage across the detector shunt resistance and drive the voltage to zero.

11. **Low inductance measurement:** This board provides a low inductance measurement capability.

Six-wire measurement

12. **Measurement range.** Range f.s.d.: 10 Ω, 40 Ω, 160 Ω, 640 Ω and 2.56 kΩ. Measurements may be made, with specification, from 20% to 120% of f.s.d.

13. **Additional inaccuracy to 4-wire specification:**

For System 80C	±0.13% x Rx/Rv ±0.5%
For System 80R	±0.21% x Rx/Rv ±0.5%
For Systems 80X and 800X	±0.40% x Rx/Rv ±0.5%

14. **Source current:** The source current limit is 50 mA.

15. **Current through Rx:**

Range f.s.d.	Current (mA)
2.56 kΩ	0.125
640 Ω	0.4
160 Ω	2
40 Ω	8
10 Ω	32

16. **Source voltage:** The source voltage varies linearly with resistance and is 320 mV at range f.s.d.

17. **Source shunt resistance:** Dependent on the source currents available and the current drawn by the resistor to be measured.

18. **Detector shunt resistance:** Rv > Rx/20.

Three-wire active guard

19. **Measurement range:**

1) Range f.s.d.: 4 kΩ. Measurements may be made, within specification, from 50% to 200% of f.s.d.

2) Range f.s.d.: 16 kΩ, 64 kΩ, 256 kΩ, 1.02 MΩ, and 4.1 MΩ. Measurements may be made, within specification, from 25% to 200% of f.s.d.

20. **Additional inaccuracy to 2/3-wire specification:**

For System 80C	
Left-hand Bay	±0.18% x Rx/Rv + 200/Rs% plus additional over 1 MΩ of ±0.5%.
Right-hand Bay	±0.18% x Rx/Rv +325/Rs% plus additional over 1 MΩ of ±0.5%.
For System 80R	±0.26% x Rx/Rv +200/Rs% plus additional over 1 MΩ of ±0.5%.
For System 80X and 800X	±0.45% x Rx/Rv + 325/Rs% plus additional over 1 MΩ of ±0.5%.

21. **Source current:** Guarding amplifier current from 0 to 2 mA.

22. **Source voltage:** The source voltage is a constant 200 mV.

23. **Source shunt resistance:** Rs > 100 Ω.

24. **Detector shunt resistance:** Rv > Rx/20.

Inductance

25. **Measurement range:** Range f.s.d.: 30 µH. Measurements may be made, within specification, from 4% to 125% of f.s.d.

26. **Frequency:** Inductance is measured at 102.4 kHz.

27. **Accuracy:** ±4% +0.3 µH, -1.05 µH

Chapter 2

INSTALLATION

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GENERAL

1. The 1968 6-Wire Measurement Kit comprises the following items:

a) A 6-wire extension board : AM22

b) Two 6-wire adapter cables : 43130-205D

c) A 6-wire measurement cable : 43130-190Y

d) Three replacement C pole motherboard links : 43129-821F

e) A self check unit modification kit : 46883-828Y

Items a,b and c are used in all installations. Item d is required only for Systems 80X/ 800X: Note that only a 2048U system uses all three links, normally two are sufficient. Item e is provided to allow you to modify your existing selfcheck unit to test the 6-wire capability. It is expected that in most instances the modifications to the selfcheck unit will be made by Marconi Instruments 'in-house', however instructions are provided with the kit to allow 'field' modifications to be made, if necessary.

2. The following sections describe how items a-d of para. 1 are fitted into an existing system. It is assumed that access to the interior of the system has been achieved by either removing panels or opening doors as detailed in the appropriate system manual. Note that instructions for fitting the additional C pole links are included with the installation instructions for cable 43130-190Y.

FITTING CABLES 43130-205

3. Two 43130-205 cables are provided: One for connection to PLB on the 6-wire extension board AM22 and one for connection to PLB on the admittance meter source board, AM5. Each cable is supplied in a plastic bag together

with suitable screws and washers to fix it into the system which is accomplished as follows:

(1) Select where the AM22 is to go : It can be plugged into either slot S1 or slot S2 in the 1838 Measuring Frame but S1 is preferred.

The following steps describe the fitting of one of the cables and should be applied for both cables in turn (i.e. to the AM22 and then to the AM5 slot, or vice-versa).

(2) Remove the dummy locator in the selected slot by unscrewing the two M3 screws holding it at the top and bottom. The locator, screws and crinkle washers may be discarded.

(3) Fold cable 43130-205 up on itself until the connectors at each end are back to back with their fixing holes in alignment.

(4) Fit the 34-way edge connector end of the cable into the 1838 chassis in the position from which the dummy was removed: Pin 1 (the marked wire of the ribbon cable) should be at the bottom. Screw both connectors down using the M3 screws and washers provided with the cable (in the plastic bag).

FITTING CABLE 43130-190

4. Cable 43130-190 connects the edge connections of AM22 into the system and breaks the C pole connections to provide four C poles if required. It also provides a connector for use by an external instrument. The cable has a number of connectors fitted which can be identified as follows:

a) A 38-way socket with 11 screened wires - connects to the AM22 edge connector cable.

b) A 38-way socket with 1 screened wire - connects to the AM5 edge connector cable.

c) A 7-way plug - for external instrument connections.

d) A 4-way socket marked C_0^1 - connects to AS1 number 1 - i.e. to the motherboard of analogue switching sub-unit number 1.

e) A 4-way socket marked C_2^3 - connects to AS1 number 2 (80C and 80R)or AS1 number 3 (80X and 800X) - i.e. to the motherboard of analogue switching sub-unit number 2 or 3.

5. The cable is installed as follows:

(1) Insert the 38-way socket with 11 screened wires onto the rearward facing plug of the 43130-205 cable fitted to spare slot S1 or S2 (see para. 3(4)). These two connectors are polarized and can only be mated in the correct orientation.

(2) Insert the 38-way socket with one screened wire onto the rearward facing plug of the 43130-205 cable fitted to the AM5 slot (see para. 3(4). These two connectors are polarized and can only be mated in the correct orientation.

(3) The seven-way plug is fitted with a bracket which can be screwed to the left side plate of the measuring frame on System 80 or to a convenient side plate of a switching frame for other systems. The plug is supplied with a free, mating socket which is intended to be connected to a cable from an external instrument: Pin connections for this purpose are given in Chap. 3, Table 1.

(4) The next step is to connect the C pole cables to the analogue switching sub-units. Different switching arrangements are used for System 80 and 80R compared to System 80X and 800X and, accordingly the two types are described separately.

System 80/80R C pole connections:

6. The following instructions apply to AS1 number 1 and AS1 number 2 which are the motherboards for analogue switching sub-units 1 and 2 respectively. They can be located as follows:

(a) System 80. Remove the rear panels from the system and the view should be as shown simplified in Fig. 1.

(b) System 80R. Remove both side panels. If two switching frames are fitted AS1's numbers 1 and 2 are the two motherboards fitted to the lowest card frame. Whatever the arrangement AS1 number 1 is associated with the lower numbered test point cards and should be the leftmost in the frame (from the printed circuit side of the motherboards). The locations of the PLC's are as shown for System 80 in Fig. 1.

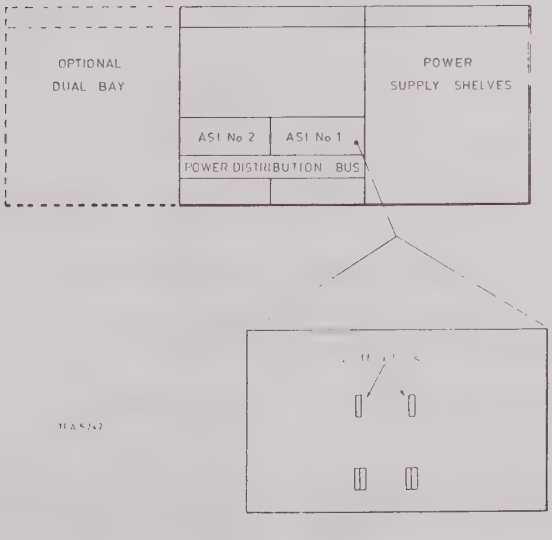


Fig. 1 Location of analogue sub-units for System 80C

7. In the systems' original (unmodified) state a single cable 43129-715J brings poles A,B,C_0 and C_1 onto AS1 number 1 from where they are distributed separately through the system. To implement the 6-wire modification the C-pole wiring has to be modified but the A and B pole wiring is untouched. The modification should be made as follows:

(1) Disconnect the existing connection to PLC(1) on AS1 number 1 (see Fig. 1) - leave this wire hanging loose or tie it back as it is no longer required.

(2) Remove and discard the two core screened cable connecting PLC(2) on AS1 number 1 and PLC(1) on AS1 number 2.

(3) Connect the four-way socket marked C_0^1 to PLC(1) on AS1 number 1.

Connect the four-way socket marked C_2^3 to PLC(1) on AS1 number 2.

In both cases the arrow on the socket should be pointing upwards.

System 80X/800X C pole connections:

8. A system 80X/800X can have several test point switching configurations, but in all cases the two analogue switching sub-unit motherboards nearest to the measuring frame (and the AM22) are AS1 number 3 and AS1 number 1. In its original state a single cable brings poles A,B,C_0 and C_1 onto AS1 number 3 from where they are distributed separately through the system. To implement the 6-wire modification the C pole wiring has to be modified but the A and B pole wiring is untouched.

9. Fig. 2 illustrates the wiring required for System 80X/800X which should be achieved as follows:

(1) Disconnect the existing connection to PLC(1) on AS1 number 3 - leave this wire hanging loose or tie it back as it is no longer required.

(2) Remove and discard the following two core screened cables:

(a) Between PLC(2) on AS1 no. 3 and PLC(1) on AS1 no. 1.

(b) Between PLC(2) on AS1 no. 1 and PLC(1) on AS1 no. 6.

(c) Between PLC(2) on AS1 no. 6 and PLC(1) on AS1 no. 5.

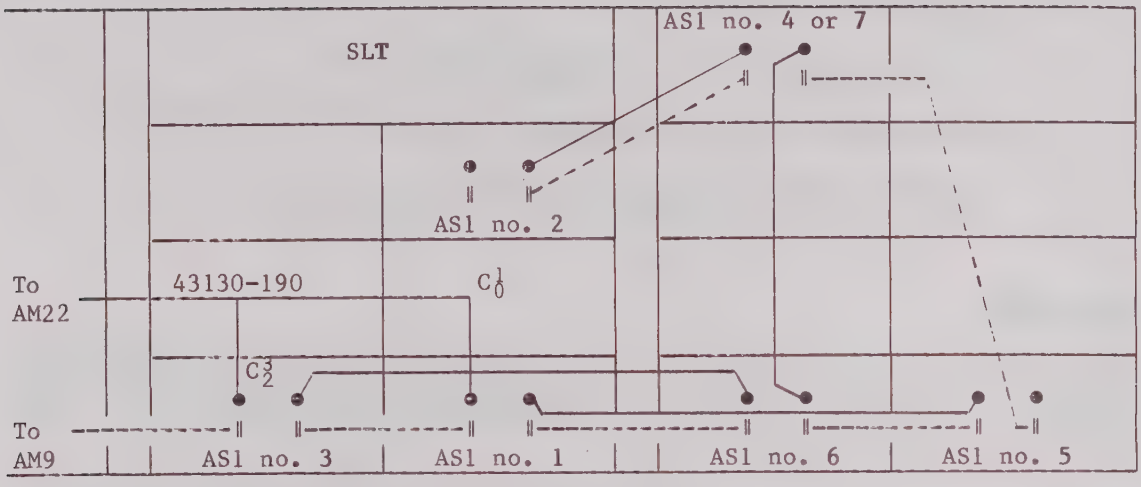
(3) Connect the four-way socket marked C_2^3 to PLC(1) on AS1 number 3 and the socket marked C_0^1 to PLC1 on AS1 number 1. In both cases the arrow on the socket should be pointing upwards.

(4) Connect two of the additional C pole links (43129-821F) as follows (again the arrow on the sockets should be pointing upwards):

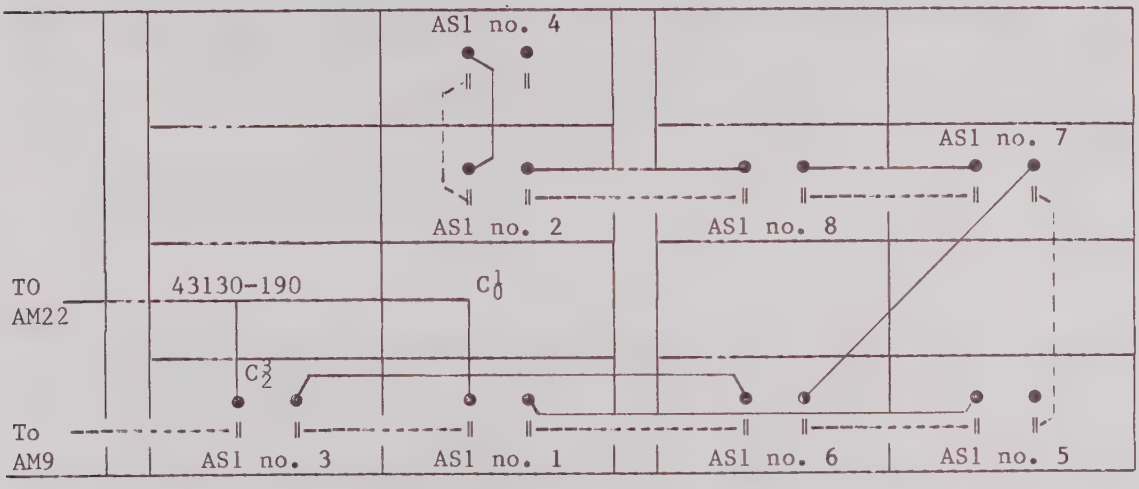
(a) From PLC(2) on AS1 no. 3 to PLC(1) on AS1 no. 6.

(b) From PLC(2) on AS1 no. 1 to PLC(1) on AS1 no. 5.

(5) Move the C pole link connection at PLC(2) on AS1 no. 5 to PLC(2) on AS1 no. 6. The location of the other end of the link depends upon the system configuration but need not be changed.



a) All systems except those with 2048U test points



b) 2048U test point systems only

View from front (of system)

Note ...

In the above layouts PLC(1) and PLC(2) are indicated by ● symbols, while PLA and PLB are indicated by ‖ symbols. Which connector is which is shown in the following sketch. The A and B pole links are unmodified and are shown dotted above as a guide to the original C pole wiring, which closely followed them.

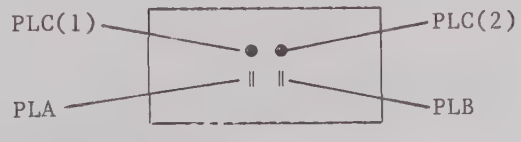


Fig. 2 System 80X/800X links for analogue switching sub-units

(6) On 2048U systems only remove and discard the two core screened cable between

PLC(2) on AS1 no. 5 and PLC(2) on AS1 no. 7

Then connect the third additional C pole link (43129-821F) from

PLC(2) on AS1 no. 6 to PLC(2) on AS1 no. 7.
(the arrow on the socket should be pointing upwards).

FINAL STEPS

10. Once cable 43130-205 has been fitted into the system, board AM22 can be fitted into its chosen place in exactly the same manner as for any other measuring frame board. Once the cables and board are fitted the 1968 6-wire Measurement Kit is available for use.

11. The equipment will need to be calibrated once it is installed: Chapter 5 gives detailed instructions on calibrating the AM22 board and the system.

12. A revised version of the selfcheck program and associated test unit are available for checking a system with 6-wire measurement capabilities: A kit for modifying the test unit is provided as part of the 1968 Kit. If this program and test unit are to hand it is recommended that you test your installation once you are satisfied with the calibration.

Chapter 3-1

OPERATION

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GENERAL

1. The 1968 6-wire Measurement Kit uses the Systems' conventional measurement techniques for d.c. resistance and it is essential that these are understood before the enhanced techniques can be described. Accordingly the first part of this chapter gives a resume of the standard measurement techniques for d.c. resistance. The low inductance measuring circuit does not use existing measurement circuits (other than a source frequency) and hence no resume is necessary.

STANDARD DC RESISTANCE MEASUREMENTS

2. A fundamental circuit arrangement shown in Fig. 1 is used to measure resistance in terms of a DC voltage.

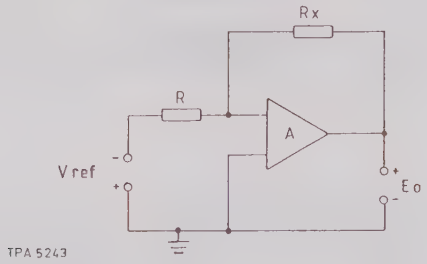


Fig. 1 Fundamental resistance measuring circuit

A is an operational amplifier, R a known value resistor, Vref a known voltage source and Rx a resistor the value of which is required to be measured.

3. A property of operational amplifiers is that when correctly connected in a feedback circuit the amplifier will try to give an output of such a voltage that it can maintain the voltage across its input terminals at zero. An ideal operational amplifier will have infinite gain, infinite input impedance and zero offset voltage at its input. In an ideal case then the operational amplifier in Fig. 1 having one input terminal connected to earth will maintain its other input terminal at earth potential. If we assume that values in the circuit are such that this state of affairs exists we can calculate the current flowing in resistor R as being $\frac{V\ ref}{R}$. This current however cannot flow into the amplifier and so must all flow through Rx causing a voltage $\frac{Vref\ Rx}{R}$ to appear across Rx. This voltage must equal the output voltage of the amplifier Eo and so

$$Eo = \frac{Vref\ Rx}{R} \qquad \text{or} \qquad Rx = \frac{Eo\ R}{Vref}$$

As Vref and R are known we can calculate Rx if we measure Eo. It will be seen that Eo varies linearly with Rx. This is a simple 2-wire method of measuring an unknown resistor.

4. Referring again to Fig. 1 it can be seen that if R is the unknown and Rx the known resistor we can use the same circuit to measure R only now $R = \frac{Vref\ Rx}{Eo}$ and the linear relation between the output voltage and unknown resistor has been lost.

5. Resistors rarely occur on printed circuit boards in isolation from other resistive components and in a typical case an unknown resistor may be shunted by one or more other resistors. Most such networks can be resolved into a triangle (or delta) of resistors as in Fig. 2.

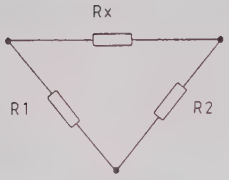


Fig. 2 Triangle of resistors

6. Consider the operational amplifier circuit Fig. 3. This is essentially the same as Fig. 1 with the addition of the 2 extra resistors R1 and R2. Neglecting small effects which will be mentioned later it can be seen that normally no current will flow through R2 as it is across the input of the operational amplifier across which there is no voltage, i.e. the operational amplifier is a virtual earth. Therefore R2 will not affect the measurement of Rx. Current will however flow through R1 from source Vref and its magnitude will depend on both Vref and R1. As long as Vref can supply additional current for R1 without losing regulation the measurement of Rx will be unaffected. This is known as guarding out the unwanted resistors R1 and R2.

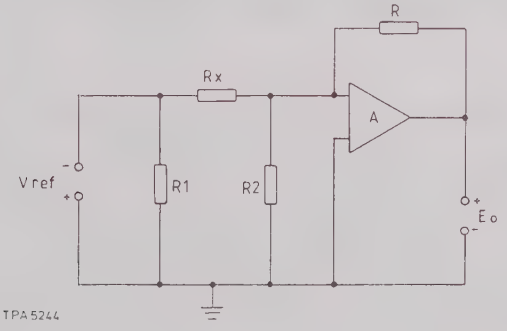


Fig. 3 Shunted resistor Op. amp circuit

7. This is the 3-wire method of measuring resistors in the System 80 family and is described more fully, along with programming information in H 54811-014T, the INCITE programming language manual (normally located in Section 2 of Volume 2 of the System manual.

8. The 3-wire method of measurement is useful without loss of accuracy down to values of Rx of the order of 1 kΩ but then the resistance of the wiring between the measurement circuit and the u.u.t. starts to become significant compared to the value of Rx. Vref is 0.2 V and has a current capacity of

about 50 mA so that the user can easily calculate in a given network how much current is spare to flow through R1. R2 also has a low limit in practice despite the fact that there is in theory no d.c. voltage across it. Very low values combine with stray and circuit capacitances to introduce error currents at mains supply and other higher frequencies.

9. A method of measuring very low resistors entitled the 4-wire method is shown in Fig. 4.

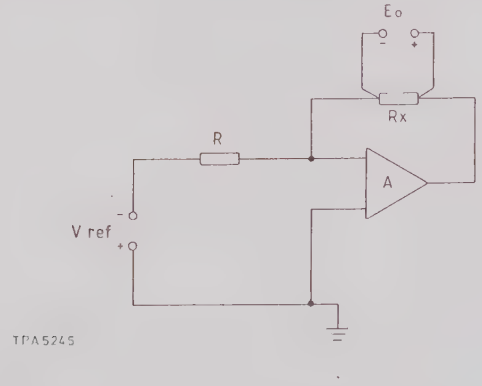


Fig. 4 4-wire low resistance measuring circuit

This method is used in the standard System 80 family and further details and programming information are given in the INCITE manual. Here 4 wires are connected to the resistor to be measured Rx, two to supply a known current defined by Vref, R and A and the other two, connected as close to Rx as possible, used to measure the voltage Eo developed across Rx.

RESISTANCE MEASUREMENTS USING THE 6-WIRE MEASUREMENT BOARD

General details

10. The System 80 family has a 4-wire analogue measurement matrix (described more fully in Vol. 2 of the instruction manual). In the 4-wire measurement described in the previous section poles A and B of this matrix are used to supply the known current and poles C_0 and C_1 are used to measure the voltage developed across Rx. If low value resistors occur in a network it is not possible in a standard System 80 series a.t.e. to make accurate measurements as all the available wires (or poles) have been used up leaving none spare for guarding out unwanted resistors as described in para. 6.

11. The AM22 6-wire measurement board provides an extra 2 wires or poles which can be used, with certain constraints, to make accurate measurement of low value resistors in a u.u.t. in networks of other low value resistors. It does not provide a full 6-wire matrix, but instead the C poles are split into two sets of two, each set being associated with a specified analogue sub-unit or sub-units. The first pair of C poles are called C_0 and C_1 as in a standard system and the second pair are called C_2 and C_3.

12. In a standard system the C poles are linked between motherboards in a daisy chain fashion. Fig. 5 illustrates this for System 80 and 80R where a logical sequence can be employed, but for System 80X/800X the dictates of neat and short cabling mean that although daisy chaining is still used, it is not between consecutive sub-units.

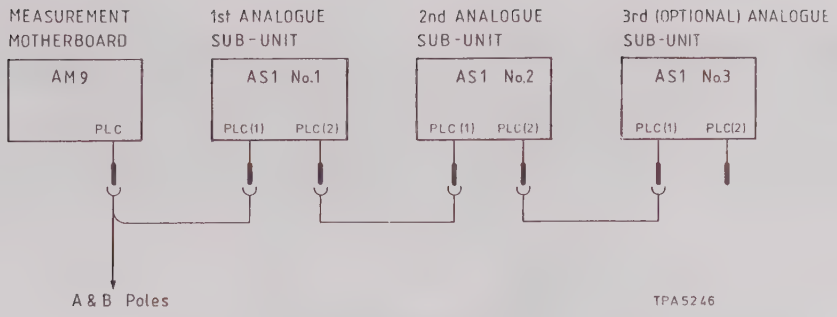


Fig. 5 Standard C-pole wiring for Systems 80C & 80R

13. When 6-wire measurement kit 1968 is fitted to System 80 and 80R all C-pole cables except the one between optional analogue sub-units 2 and 3 are disconnected and replaced by cable 43130-190 which is part of the kit. The resulting C-pole wiring then is as depicted in Fig. 6. For System 80/800X the cables are arranged so that analogue sub-units 1 and 5 (i.e. the first on each interface) have the same C-pole pair while all the other sub-units have the other pair.

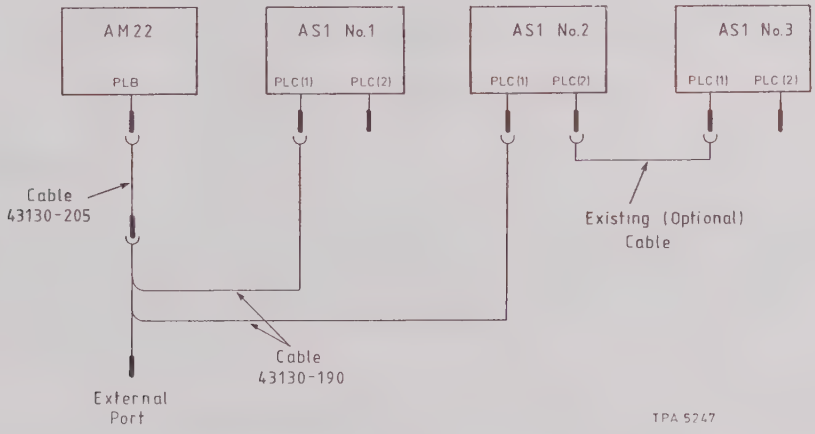


Fig. 6 System 80/80R 6-wire C-pole wiring

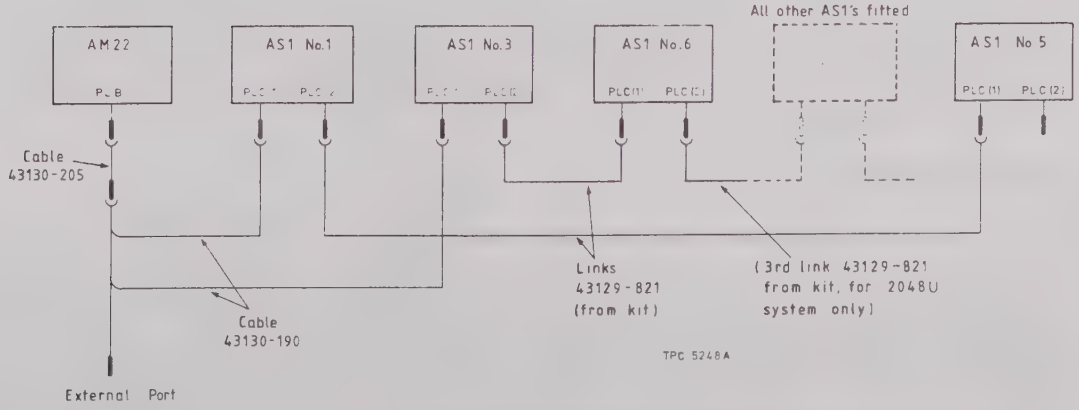


Fig. 7 System 80X/800X 6-wire C pole wiring

14. The effect of these changes is that the test points on the first and fifth analogue sub-units (i.e. 0-255 and 1024-1279) are dedicated to poles C_1 and C_0 while all other test points are dedicated to C_2 and C_3. For the types of d.c. resistance measurement described previously this should not cause any problems since the basic configurations can be achieved with either pair. However the extra poles do allow measurement in the following modes to be made:

a) 5-wire measurement
b) 6-wire measurement
c) Active guard 3-wire measurement

These modes of measurement are detailed in the following sections.

5-wire measurement

15. Fig. 8 shows schematically how 5-wire measurement is made.

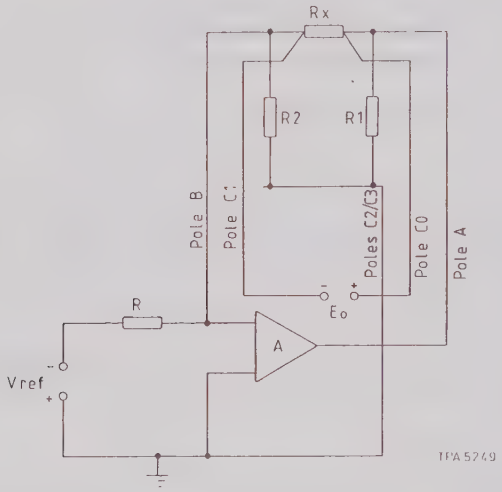


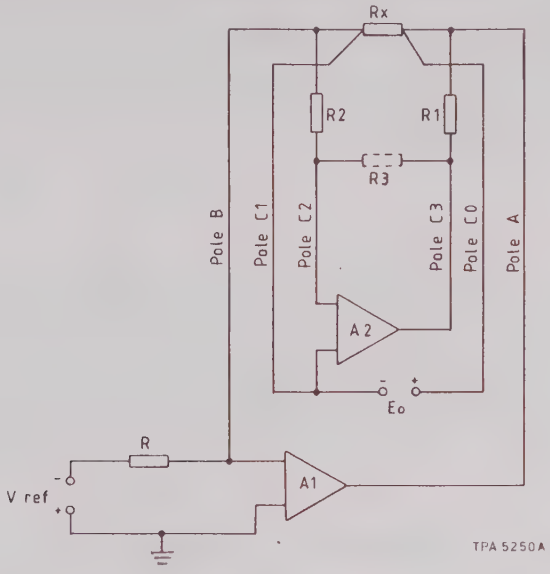
Fig. 8 5-wire measurement

An improvement in measurement accuracy over 3-wire and 4-wire modes is achieved for ranges of values of Rx, R1 and R2 but if R1 is drawing considerable current there will be a voltage drop along the C_2/C_3 poles due to wiring resistance. This voltage drop will appear across R2 and be only partially cancelled by the voltage drop along the C_1 pole. The resulting voltage across R2 will cause current to flow through it, this current being deducted from the reference current which should flow entirely through Rx causing a low reading to be made.

6-wire measurement

16. 6-wire measurement is depicted in Fig. 9. Poles A,B,C_0 and C_1 are connected as for 4-wire and 5-wire measurement. A second operational amplifier is introduced, its input connected across R2 via poles C_1 and C_2 and its output connected to the common point of R1 and R2. This second operational amplifier drives the common of R1 and R2 so as to maintain zero potential across R2. In this way measurement of resistors in a range of less than 1 Ω to over 2 kΩ in the presence of low resistance shunt paths can be made with small loss of accuracy compared to a straight 4-wire measurement of

an isolated Rx. Indeed with some values of Rx and R1, R2 can decrease to a few milliohms without affecting the measurement.



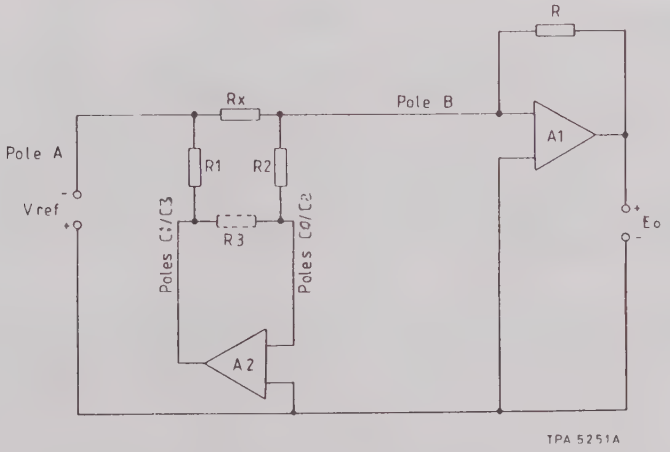
Note ...

R3 represents the low value resistance of wiring/track on the u.u.t. between poles C_2 and C_3. To achieve best results C_2 must be nearer to R2 than C_3.

Fig. 9 6-wire measurement

3-wire active guard

17. 3-wire active guard is similar to the 3-wire passive guard method of measurement described in para. 6 and is most useful for improving accuracy of measurement of resistors over 1 or 2 kΩ in networks with other resistors. Again a second operational amplifier is used to sense the voltage across R2 and to drive its common point with R3 so that no potential exists across R2. A schematic is shown in Fig. 10.



Note ...

R3 represents the low value resistance of wiring/track on the u.u.t. between poles C_2 and C_3. To achieve best results C_2 must be nearer to R2 than C_3.

Fig. 10 3-wire active guard

18. 3-wire active guarding cannot eliminate errors caused by lead resistance and, with certain combinations of resistors, this may become significant. For example, in Fig. 10 if the lead resistance of pole A (Vref(-) to R1/Rx) is 1 Ω (say) and R1 is 100 Ω then the resultant potential divider will cause a 1% discrepancy in Vref, and hence in the measured value. As the value of R1 increases so the effect of the lead resistance decreases. It is recommended that 3-wire active guard measurements are only made where R1 is not less than 100 Ω and R2 is not less than Rx/20.

External measurements

19. The AM22 board provides facilities for measurements to be made by an external instrument such as a d.v.m. Chapter 3-2 gives details of the various relays which can be shut to allow the external connections whilst Chap. 4 Fig. 5 is a schematic diagram illustrating the connections made for external 5 and 6-wire measurements. Table 1 gives the pin connections for the external plug/socket provided as part of the 6-wire measurement kit.

TABLE 1 EXTERNAL PORT PIN CONNECTIONS

Pin	Function
E	Voltage measurement (-)
D	Voltage measurement (+)
H	Guard sense
F	Current source (-)
A	Guard
C	Current source (+)
B	Commoned screens

Test point allocation

20. There are constraints in test point allocation of which the user must be aware. Essentially Poles A and B have no restriction and are used normally. Poles C_0 and C_1 are restricted to even numbered and odd numbered test points respectively as in normal usage. Similarly Poles C_2 and C_3 are restricted to even numbered and odd numbered test points respectively. Further restrictions apply to the range in which these poles can be assigned. These are detailed in Table 2.

TABLE 2 ALLOWED C POLE TEST POINTS

Test point range		System		
		80 series	80 R	80X/800X
0		Reserved for current probe		
1 - 255	even	C_0	C_0	C_0
	odd	C_1	C_1	C_1
256 - 767	even	C_2	C_2	C_2
	odd	C_3	C_3	C_3
768 - 1023	even	-	-	C_2
	odd	-	-	C_3
1024 - 1279	even	-	-	C_0
	odd	-	-	C_1
1280 - 2047	even	-	-	C_3
	odd	-	-	C_3

LOW INDUCTANCE MEASUREMENTS

21. The low inductance measuring facility utilizes switching provided by the AM22 6-wire measurement board to apply a 102.4 kHz signal from the AM5 Admittance Meter Source board to the unknown inductor. The voltage across the inductor is then amplified and converted to a d.c. level on the AM22 board and passed on to the system ADC for resolution. Fig. 11 is a simplified diagram of this process.

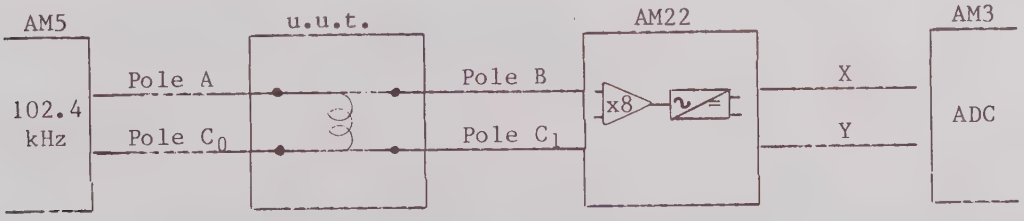


Fig. 11 Block diagram of low inductance measurement

22. The calibration of the measuring system is such that a 30 μH inductance produces a voltage of 25 mV a.c. which is eventually applied to the ADC as 200 mV d.c. If the inductance/ADC input voltage relationship is linear then it can be said that

$$\frac{3}{20} \times \text{ADC reading in mV} = \text{Inductance in } \mu\text{H}$$

This conversion can be integrated into a programming statement to give a direct reading for the operation. Programming is explained in Chapter 3-2.

Chapter 3-2

PROGRAMMING

CONTENTS

Para.
1 Introduction
4 Relay control
6 Making measurements
6 Notes
6 Delay statements
7 C-poles
8 Standard resistance measurements
8 Programming 5 and 6-wire measurements
10 Active guard 3-wire measurement
11 Programming line comparison
12 External measurements
13 C-pole settings
15 Low inductance measurements
17 Resetting the system after using the AM22 board

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1 Relay control board 2
2 Mode settings 2
3 C-pole settings 3

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1 Circuit for 6-wire programming example 4
2 Circuit for programming comparison 5

INTRODUCTION

1. Control of the 6-wire measurement board is accomplished by using the INCITE SNDIFC verb in conjunction with the code letter Y and a data word. There are 22 relays (code A to Z) on the AM22 board and each can be individually set/unset by the data word. However as it would be tiresome to keep defining the individual relays, a facility is incorporated which allows you to specify what mode of measurement you want (i.e. 5-wire, 6-wire, external 5-wire, etc.) and the required relays are activated automatically. In addition a further facility allows you to specify certain preset types of C-pole switching (i.e. the relay combination required).

2. If you do not wish to use the predefined setting arrangements, two "free" modes are available which allow you to specify, by means of dedicated bits in the data word, the precise relay you wish to close: One free mode applies to all relays while the other allows the predefined C-pole switching facility to be imposed.

3. The data word is 14 bits long of which the first 6 are allocated as mode and C-pole definition. To allow the 21 relays to be specified sign bits are used to provide an additional 14 bits. The default is Y+ and hence Y- is only used in a free mode setting situation. Refer to the circuit diagram (Chap. 7) and/or to the technical description given in Chap. 4 for details of the individual relays and their effects.

RELAY CONTROL

4. The words used to control the AM22 board are shown in Table 1. These words are presented as up to 5 octal digits each: The relay setting bits are dedicated in each number but leading zeroes are assumed, i.e. the words justify from the right. Table 2 defines the various modes called up by bits 0 - 2 of the Y+ word and also shows which relays are closed in that mode. Table 3 defines the C-pole setting codes called up by bits 3 - 5 of the Y+ word and again shows which relays are closed.

TABLE 1 RELAY CONTROL WORD

Bit	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Y(+) Relay	Y	X	W	V	T	S	R	P	-	C-pole			Mode		
Y-	-	Z	N	M	L	K	J	H	G	F	E	D	C	B	A

TABLE 2 MODE SETTINGS

Mode number	Measurement type	Relays set (marked X) N	P	R	S	T	V	W	X	Y
0	Free mode with set C-pole switching (see Table 3)									
1	External: 5-wire	X	-	-	-	-	-	X	X	X
2	External: 6-wire	-	-	-	-	-	-	X	X	X
3	External: 5/6-wire	-	-	-	X	X	X	X	-	X
4	Active guard 3-wire	-	-	-	-	X	X	-	-	-
5	5-wire	X	X	-	-	-	-	-	-	-
6	6-wire	-	-	X	-	X	X	-	-	-
7	Free mode with free C-pole switching									

5. Modes 1-3 and 5-6 in Table 2 are conventionally used with a C-pole setting of 1, though the other settings are allowed. Thus for these measurements only the commands Y11, Y12, Y13, Y15 or Y16 are necessary. Mode 4 is associated with a C-pole setting of 5 for 3-wire active guard measurements and Y54 must be called to achieve this. Y70 is reserved for low inductance measurements.

TABLE 3 C-POLE SETTINGS

Code number	Relays set (marked X)													
	A	B	C	D	E	F	G	H	J	K	L	M	U	Z
0	X	-	-	X	X	-	-	X	-	-	-	-	-	-
1	X	-	-	X	-	-	-	-	-	-	X	X	-	-
2	-	X	X	-	-	-	-	-	-	-	X	X	-	-
3	-	-	-	-	X	-	-	X	X	X	-	-	-	-
4	-	-	-	-	-	X	X	-	X	X	-	-	-	-
5	-	-	-	-	-	-	-	-	X	X	X	X	X	-
6	User selectable													
7	X	-	-	X	X	-	-	X	-	-	-	-	-	X

MAKING MEASUREMENTS

Notes

Delay statements

6. For low inductance measurements a delay of 50 ms is necessary, i.e. a

DELAY 50

statement is required, to allow the circuit to stabilize.

C-poles

7. When making measurements it should be borne in mind that the C-poles latch and either CLEARGUARD, GUARD (-TP) or SNDIFC "@" must be used to remove unwanted C-poles.

Standard resistance measurements

Programming 5 and 6-wire measurements

8. Programming 5-wire and 6-wire measurement modes is basically the same as 4-wire measurement programming but in addition the 5-wire mode or 6-wire mode has to be called and so also do the test points for the C_2 and C_3 poles. To give an example of a typical 6-wire measurement statement consider the circuit shown in Fig. 1.

14. Following are two examples of the use of these additional standard C-pole setting codes:

(1) Y26 will call a 6-wire measurement where the C_0 and C_1 poles, instead of being associated with even and odd numbered test points respectively, are associated with odd and even.

(2) Y32 will call for a 6-wire measurement using an external measuring instrument with guarding handled by test points in the lower range of 1 to 255 and voltage measurement in the high range of 256 upwards.

Low inductance measurements

15. The low inductance measuring circuits are set up by using the completely free switching mode (mode 7) to switch relay RLZ and the C-pole relays. Following is an example program where three inductors are to be measured and checked against specified limits: An explanation of the lines is given in para. 16.

```
3010  RESET : REM LOW INDUCTANCE TESTS
3020  REM D1 = VALUE, D2 = SYM.TOL
3030  PRINT : PRINT TAB(10), "LOW INDUCTANCE TEST" : PRINT
3040  LET M$ = "0,0,0,0,0,0,0,0": CLEARGUARD
3050  SNDIFC "Y70;": REM SET LOW INDUCTANCE MODE
3100  DCV "L1-L".1V,%5: LET L = -.01: LET H = .3: LET"MX"$ = M$ $
3110  LET "POLE.A" = 141: LET "POLE.B" = 144: GUARD (257,272) $
3120  DELAY 50
3130  LET D1 = 5.5: LET D2 = 4
3140  GOSUB 600
3200  DCV "L2-L" .1V,%5: LET L = -.01: LET H = .3: LET "MX"$ = M$ $
3210  LET "POLE.A" = 257: LET "POLE.B" = 272: GUARD(-257,-272,142,145) $
3220  DELAY 50
3230  LET D1 = 12
3240  GOSUB 600
3300  DCV "L3-L" .1V,%5: LET L = -.01: LET H = .3: LET "MX"$ = M$ $
3310  LET "POLE.A" = 145: LET "POLE.B" = 142: GUARD(-142,-145,259,274) $
3320  DELAY 50
3330  LET D1 = 30
3340  GOSUB 600
3400  CLEARGUARD

 600  LET V$ = " "
 610  LET R = INT (R * 30000/2)/100
 620  IF R> D1 * (1+D2/100) THEN LET V$ = "FAIL"
 630  IF R< D1 * (1-D2/100) THEN LET V$ = "FAIL"
 640  IF V$ = "FAIL" THEN LET E = E+1
 650  PRINT D1, "UH",TAB(20),R,TAB(40),V$
 660  RETURN
```

16. Explanation of low inductance program lines:

a) Main program

Lines 3010 to 3030 Preliminary "helpful" statements

3040 Set up a string internal variable, M$, with a reset string for later use. Also clear all pole-C settings.

3050 Set Y70 for low inductance measurement mode.
Relay Z configures the board for low inductance testing.

3100 DCV is used as a convenient method of ranging the ADC and should always be set to .1 V.
The first two LET statements define high and low limit for DCV - these should be set fairly wide apart to eliminate the possibility of the inductance measurement producing an out-of-limits DCV result (the limits are NOT those for the inductance measurement).
The third LET statement uses the M$ string set in line 3040 to clear the matrix settings (DCV sets poles A and B to the ADC).
The final $ continues the setting up on the next line.

3110 Sets the matrix connections to the test component and continues on the next line.

3120 Delays the test by an extra 50 ms to allow the circuit to settle.

3130 This line defines the value of the component (D1) and its % tolerance (D2) ready for a comparison with the measured result.

3140 Directs the program to a sub-routine where the measurement result is evaluated and output.

3200 to 3240 and 3300 to 3340 These lines repeat lines 3100 to 3140 for the second and third components. Note that in lines 3210 and 3310 the previously set guards are first removed before the new ones are added. Also in lines 3230 and 3330 the tolerance is carried over.

3400 CLEARGUARD returns the system to normal operation.

b) Sub-routine

Line 600 Initial definition of string variable V$ as a blank.

610 Converts the measured result to an integer equivalent to value of the component in µH.

620 and 630 Compares the measured result with the high and low limits and, if out of limits, sets the string variable V$ with a Failed indication.

640 If an out of limits result was obtained then the error count is incremented.

650 Prints out the expected value, the measured value and either blank or FAIL depending on the results of lines 620/630.

660 Return to the main program.

RESETTING THE SYSTEM AFTER USING THE AM22 BOARD

17. A return to normal system operation after using the AM22 (i.e. AM22 is completely transparent to the C-poles, and only C_0 and C_1 exist) is brought about by any of the following statements:

(a) RESET

(b) CLEARGUARD

(c) Any measurement verb

(d) SNDIFC "GXXXXX"

(e) SNDIFC "@"

(f) SNDIFC "YXXXXO"

The latter three statements mean the appropriate letters followed by up to any 5 octal digits except (f) where the last digit must be 0.

Chapter 4

TECHNICAL DESCRIPTION

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1 General
3 AM22 decoding circuits
6 DC resistance measurements
7 Low inductance measurements

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2 Relay switching, 5-wire measurement 3
3 Relay switching, 6-wire measurement 4
4 Relay switching, 3-wire active guard 4
5 Relay switching, external 5-wire and 6-wire 5
6 Relay switching, external 5-wire using guard drive amplifier ... 5
7 Schematic of low inductance measurement 6

GENERAL

1. The code letter Y is used to give control of the AM22 6-wire measurement board. This letter, and its associated data word can open or close any relay (in any combination) on the board. Fig. 1 is a block diagram of the measuring circuits showing where the relays function in the circuit: A full circuit diagram is given in Chap. 7 whilst Chap. 3-2, Tables 1,2 and 3 give information on the various relay combinations and settings that can be achieved by the preset programming codes.

2. The AM22 board circuit can be divided into three functional areas:

(1) Decode circuits to determine what set of measurements is to be made.

(2) Circuits concerned with d.c. resistance measurements.

(3) Circuits concerned with low inductance measurements.

The remainder of this chapter describes the functions of the board under these headings.

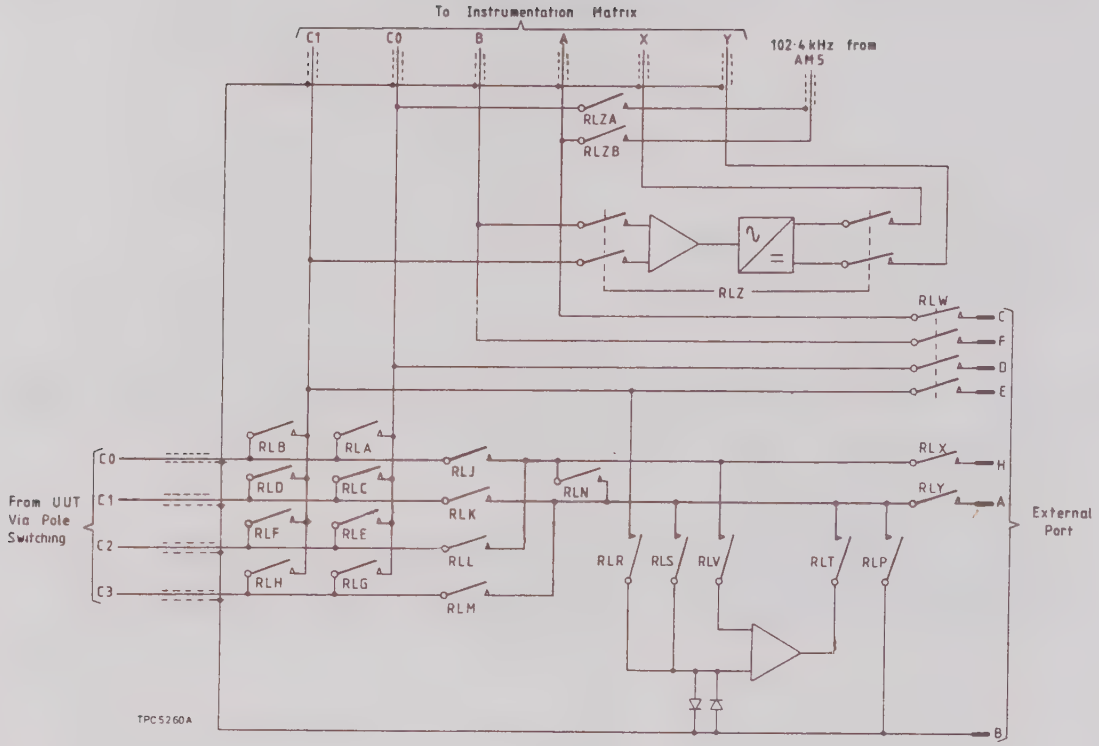


Fig. 1 Block diagram of AM22 measuring circuits

AM22 DECODING CIRCUITS

3. The letter Y from the address bus along with the sign bit from the data bus are decoded in IC3 to give Y+ and Y- signals. These are gated with STROBE in IC5 to give a Y+ CLOCK, a Y- CLOCK and a Y CLOCK. The Y+ CLOCK is used to clock data into the Y+ register bits 0-5 in IC25 and the Y- CLOCK is used to clock data into the Y- register bits 0-14 in ICs 21 & 22. The higher bits 6-14 are clocked into the Y+ register ICs 23 and 24 by a DELAYED Y+ CLOCK. This delay of 2.5 ms is generated by IC1. The three least significant bits of the Y+ register are known as the mode bits and the three next most significant bits are known as the C-pole set bits. If the mode bits decode to anything other than 7 then the upper part of the register (bits 6-14) are held cleared. Likewise only C-pole set codes 0 or 7 will allow individual C-pole relays to be called. All mode codes 0 to 6 inclusive and C-pole set codes 1 to 6 inclusive call predetermined combinations of relays. These combinations are arranged to produce suitable relay closures for the various operating modes of the AM22 and diode patch boards are included on the board to select relays in the necessary combinations.

4. Another function of IC1 is to produce a 2.5 ms pulse every time a Y code is received followed by a second 2.5 ms pulse. The first pulse is used to switch off the +24 V supply to all on board relay coils, i.e. to cause all relays to open for 2.5 ms. This is done by using the pulse to switch off TR1. Also the two consecutive 2.5 ms pulses are combined in IC6 to produce a 5 ms HOLD pulse used to prevent the system controller sending any more bus instructions until the AM22 relays have settled.

5. Any of the following will cause both Y+ and Y- registers to be reset.

(a) Bus reset

(b) Power-up detected by IC4 and C8,R14,R15

(c) Any G instruction received

(d) Any @ instruction received

(e) Instruction YXXXO - i.e. mode code 0

The reset condition isolates the AM22 active circuits from the system poles and also causes the AM22 to become transparent to normal system matrix signals.

DC RESISTANCE MEASUREMENTS

6. IC30 along with TR4, TR5 form an operational amplifier which is used for both external and internal 6-wire and internal 3-wire active guard measurements. Figs. 3,4,5 and 6 show in schematic form the essential details of the relay switching used in the various defined modes. Fig. 1 shows in schematic form all the relays together with the operational amplifier and external port. With this diagram you can determine other arrangements of C-pole switching which may cater more efficiently for your requirements: If necessary you can add further diodes (type 1N4148) to the patch board to achieve this.

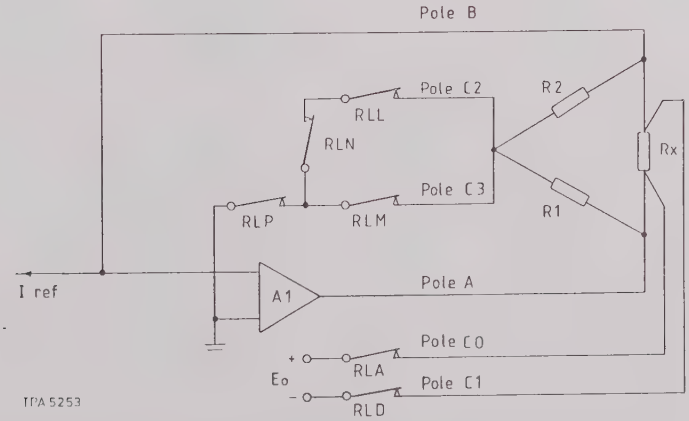


Fig. 2 Relay switching, 5-wire measurement

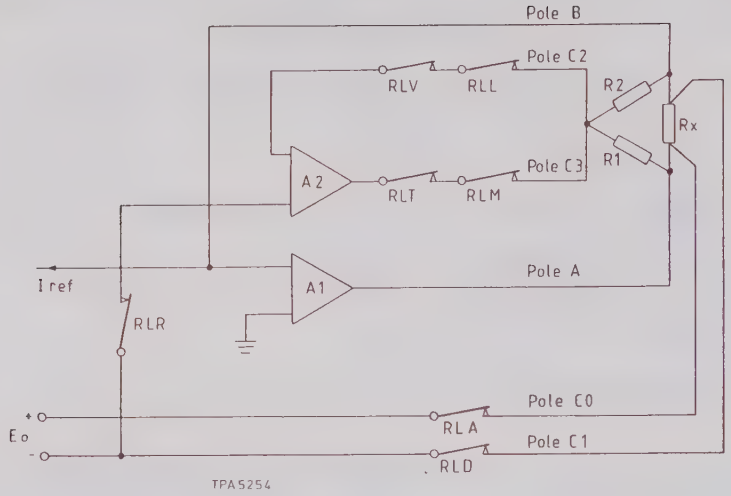


Fig. 3 Relay switching, 6-wire measurement

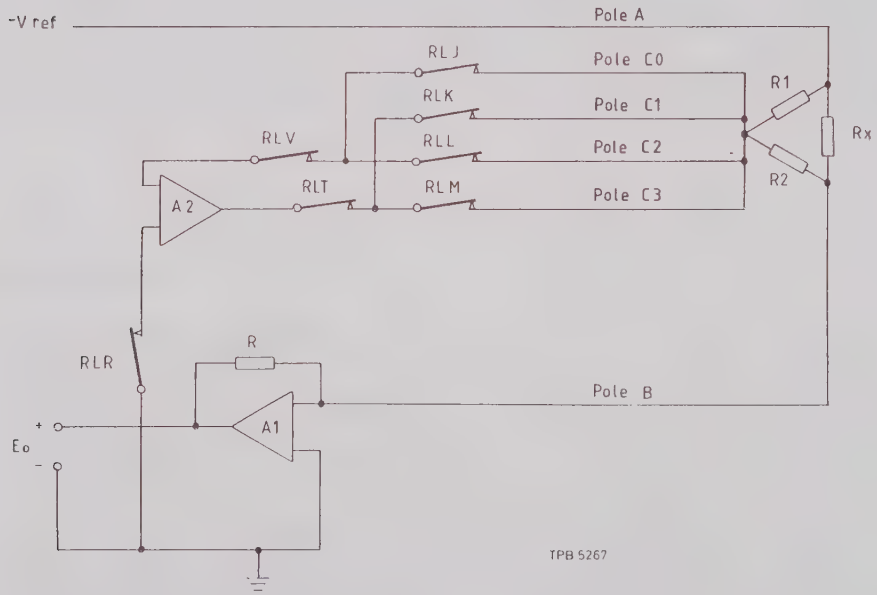
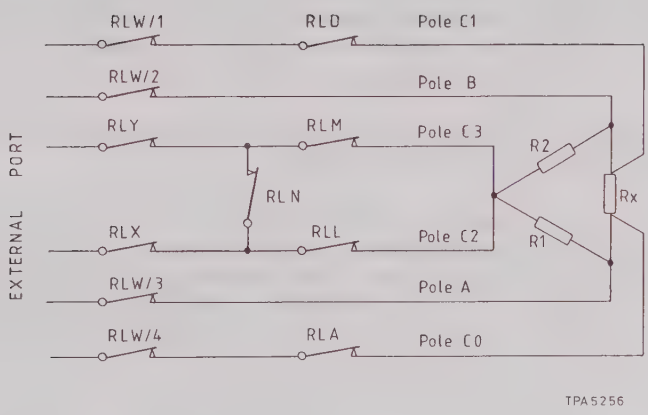


Fig. 4 Relay switching, 3-wire active guard



Note ...

RLN is closed for 5-wire and open for 6-wire

Fig. 5 Relay switching, external 5-wire and 6-wire

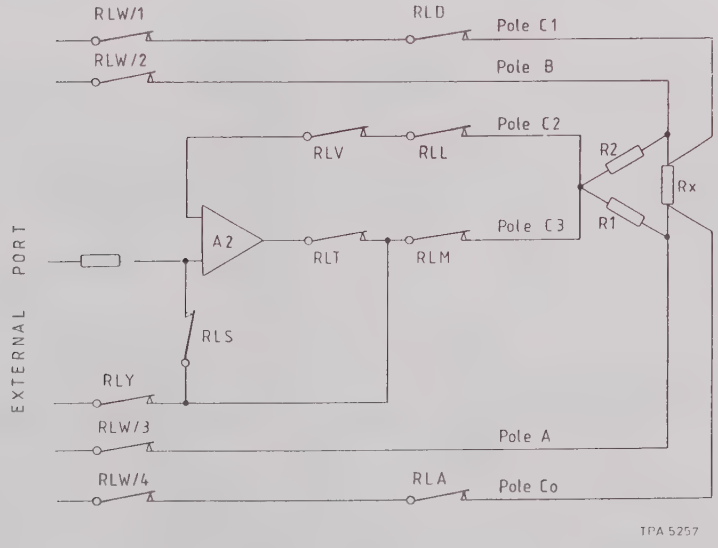


Fig. 6 Relay switching, external 5-wire using guard drive amplifier

LOW INDUCTANCE MEASUREMENTS

7. The low inductance measurement circuit is in two parts:

(1) A high impedance, variable gain instrumentation amplifier with differential inputs and high common mode rejection. This is formed by the three operational amplifiers IC31, 32 and 33 and associated components.

(2) An AD636KH RMS/DC converter which takes the output of the amplifier and converts it to d.c. for analysis.

8. A low inductance measurement is made by passing a 102.4 kHz current through the component and monitoring the voltage developed across it. Fig. 7 is a schematic diagram illustrating how the various elements of the measuring circuit are called up. Thus the 102.4 kHz current is produced on the AM5 board and taken to the AM22 board via a screened cable. On the AM22, RLZA and RLZB are closed thus allowing current to flow via Pole A, through the inductor under test, returning via Pole C_0, PLZB and the screen to AM5. Poles B and C_1 are connected close to the component and also, with RLZ closed, to the input of the instrumentation amplifier. The a.c. voltage across the inductor is amplified and converted to a d.c. level before being placed on the X and Y poles of the matrix, again by RLZ being closed, for the system's ADC to process.

9. The gain of the amplifier, which is a nominal 8, is set by variable resistor R26 while the common mode rejection can be adjusted using R30. The output from the RMS/DC converter is such that 200 mV measured at the ADC is equivalent to an inductance value of 30 µh.

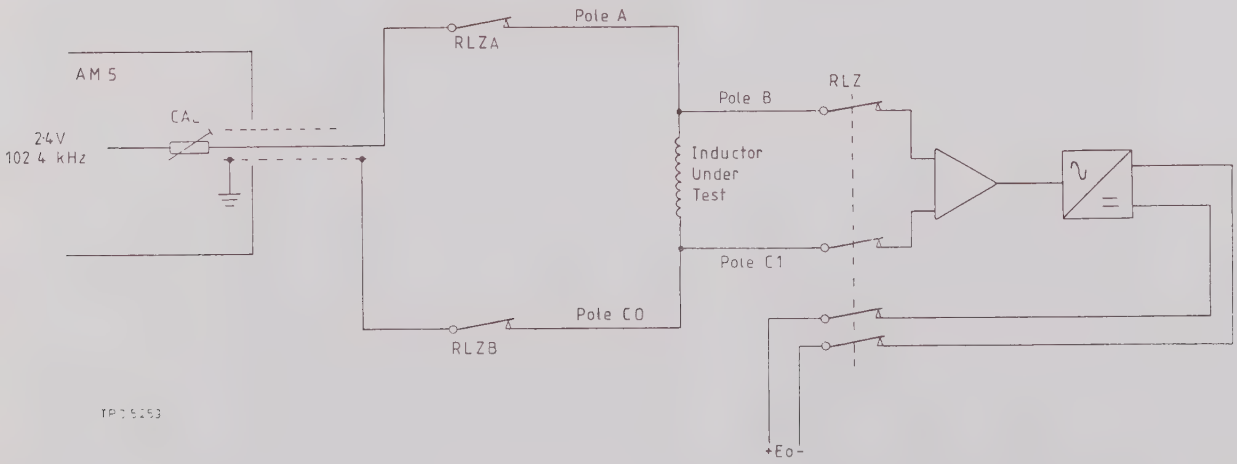


Fig. 7 Schematic of low inductance measurement

Chapter 5

MAINTENANCE

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1 General
2 Adjustments
2 AM22 board
4 Common mode rejection
6 Gain adjustment
7 Null adjustment
9 AM5 board
12 Selfcheck

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3 6-wire null adjustment connections 4
4 3-wire active guard null connections 5

GENERAL

1. A complete circuit diagram of the AM22 board is given in Chap. 7 and should suffice, with the description of method of use, etc. given in Chap. 4 to locate any faults on the board. Chap. 2 gives details of the wiring to and from the board. A selfcheck unit and program are available for checking the board in use and are briefly described at para. 12. The remainder of this chapter describes the various adjustments and calibration procedures that can be made.

ADJUSTMENTS

AM22 board

2. There are three adjustments to be made on the AM22 board as follows:

(1) Set the common mode rejection of the low inductance measuring circuit.

(2) Set the gain of the low inductance measuring circuit's amplifier.

(3) Null adjustments on the 6-wire measurement amplifier.

All of the above adjustments can be made with the board connected to the system via an extender board: This description assumes that the system's facilities are available. Adjustments 1 and 2 may, however, be more

convenient to make out of the system; in which case you will need to provide a 5 V, 3 A d.c. power supply which should be connected across PLA pins 40/39 (+5 V) and 45/44 (0 V).

3. Fig. 1 illustrates a circuit suitable for making the low inductance adjustments. Table 1 lists the equipment required.

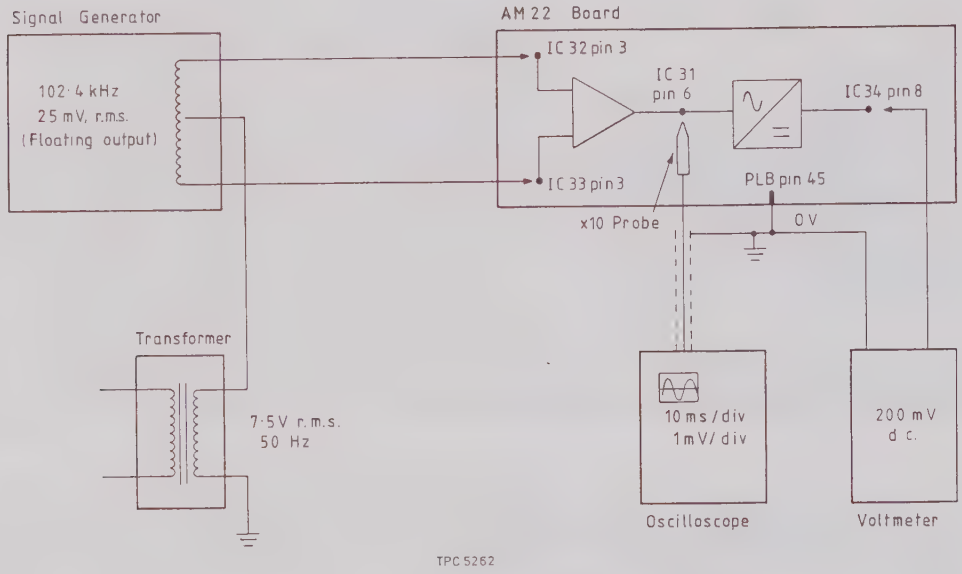


Fig. 1 AM22 low inductance adjustments circuit

TABLE 1 EQUIPMENT REQUIRED FOR AM22 ADJUSTMENTS

Item	Description	Example
a	AF oscillator with floating centre-tapped output capable of giving 25 mV, r.m.s. at 102.4 kHz	TF 2000
b	Transformer providing approx. 7.5 V r.m.s. 50 Hz	Any
c	General purpose oscilloscope with a x10 probe to monitor 50 Hz modulation on 102.4 kHz carrier	Any
d	DC voltmeter capable of reading 200 mV	Any
e	100 Ω and 10 Ω resistors for null adjustments	Any
Note:	Item (e) connects to the interface and hence some form of fixturing arrangement will be necessary.	

Common mode rejection

4. With the equipment set up as shown in Fig. 1 use the x10 probe of the oscilloscope to monitor the waveform at the output of the instrumentation amplifier (IC31,pin 6). With the 'scope set to 10 ms and 1 mV per division the measured waveform should be similar to that shown in Fig. 2.

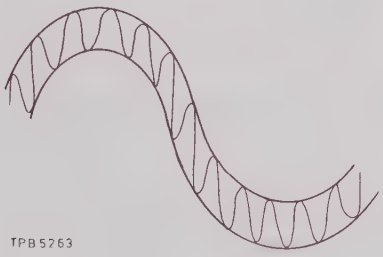


Fig. 2 Common mode waveform

5. Adjust potentiometer R30 to bring the modulation to a minimum (i.e. the waveform is linear).

Gain adjustment

6. Using the configuration shown in Fig. 1 monitor the output of the r.m.s. to d.c. converter (IC34,pin 8). Adjust potentiometer R26 so that the voltmeter gives a reading of approximately 200 mV d.c. This should give an amplifier gain of 8. No adjustment tolerances are given as accurate inductance calibration is done on the AM5 and is described later - see para. 9.

Null adjustment

7. 6-wire measurements: Null adjustments are made with the potentiometer R47. The procedure involves two resistors in the circuit shown in Fig. 3. Here six different test points are required, TPA and TPB can be any that are suitable, TPC_0 and TPC_1 must be in the range 1 to 255 and must be even and odd numbered respectively and TPC_2 and TPC_3 must be above 255 and similarly even and odd numbered. The adjustment procedure is as follows:

(1) After allowing 30 minutes for the system to warm up connect a 100Ω resistor to the system fixture interface as described above.

(2) Use the system to measure the value of the resistor (displayed on the 1803 Control Panel) as follows:

a) Set the system to stop and cycle on test mode.

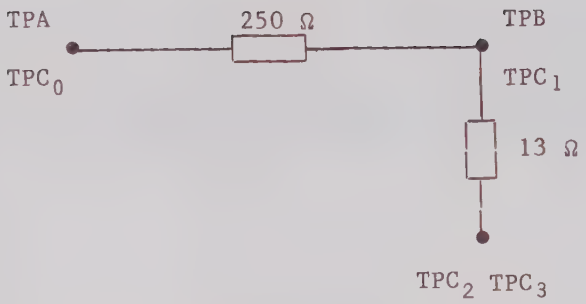


Fig. 3 6-wire null adjustment connections

(b) Execute the following program where TPA, B, C_0, C_1, C_2, and C_3 are defined above. Note the reading on the 1803 Control Panel.

```
10  REF 0
20  RES 250,%10(TPA,TPB, F TPC0, TPC1)$
30  SNDIFC "Y16;":GUARD(TPC2,TPC3)
40  PAUSE: GOTO 20
```

(3) Connect a 13 Ω resistor into the circuit as described above.

(4) Set the system to CYCLE ON TEST and run the test program again.

(5) Adjust R47 until the reading on the 1803 is the same as was achieved at step (2)b.

8. **3-wire active guard measurements:** Null adjustments are made with the potentiometer R48. The procedure involves two resistors in the circuit shown in Fig. 4. Here four different test points are required, TPA and TPB can be any that are suitable, TPC_0 and TPC_1 must be in the range 1 to 255 and must be even and odd numbered respectively. The adjustment procedure is as follows:

(1) After allowing 30 minutes for the system to warm up connect a 4 kΩ resistor to the system fixture interface as described above.

(2) Use the system to measure the value of the resistor (displayed on the 1803 Control Panel) as follows:

a) Set the system to stop and cycle on test mode.

b) Execute the following program where TPA, B, C_0 and C_1 are as defined above. Note the reading on the 1803 Control Panel.

```
50 REF 0
60 RES 4K,%10(TPA,TPB, G TPC0,TPC1):SNDIFC"Y54;"
70 PAUSE: GOTO 50
```

(3) Connect a 200 Ω resistor into the circuit as described above.

(4) Set the system to CYCLE ON TEST and run the test program again.

(5) Adjust R48 until the reading on the 1803 is the same as was achieved at step (2)b.

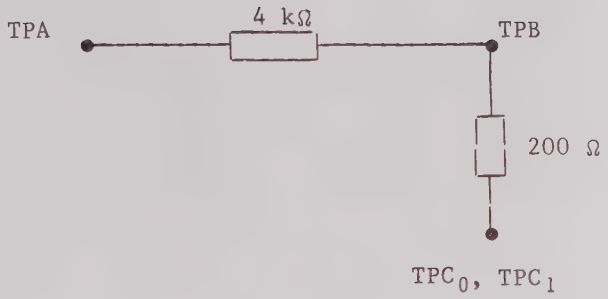


Fig. 4 3-wire active guard null adjustment connections

AM5 board

9. Potentiometer R123 located in the bottom left hand corner of the AM5 Admittance Meter Source board has to be adjusted to gain an accurate reading of inductance once the AM22 board has been set up (i.e. by adjusting the source of the measuring signal you set up an accurate output). An extender card is required for System 80 and 80R and is recommended for Systems 80X and 800X. Other equipment necessary is:

a) A precision inductor of around 30 μH whose value is accurately known.

b) Four screened wires.

c) A method of connecting item (b) to the fixture interface.

10. Use the screened wires to connect poles A and B to one end of the inductor and Poles C_0 and C_1 to the other end. Note that NONE of the selected test points should be on the same switching board. Then set the system to CYCLE ON TEST and run a test program similar to that described in Chapter 3-2 for low inductance tests.

11. Adjust R123 until the reading on the v.d.u. is the same as the known value.

SELFCHECK

12. A revised selfcheck unit and program are available to test a system which incorporates a 1968 6-wire Measurement Kit. If the option is incorporated at build time then the program and test unit supplied with the system will be the revised version. If the kit is to be 'field fitted' then the existing self-check unit should either be modified or a new one obtained and the self check program rebuilt using BUILD.INC.

13. The modification is primarily concerned with fitting a new board, AM16D, into the selfcheck unit box. This board contains a number of defined components, including precision inductors and is intended to exercise all capabilities of the 6-wire measurement kit. Full details on carrying out the modification are provided with the selfcheck modification kit. A circuit diagram for the AM16D is included in Chap. 7.

14. Segments 9992/9992X (Matrix test) and 9997/9997X (Resistance and Admittance tests) of the standard selfcheck programs have been enhanced to include tests on the modified version of the selfcheck unit. BUILD/BUILDX.INC and 9990/9990X.MST have similarly been upgraded.

Chapter 6

REPLACEABLE PARTS

CONTENTS

Para.
1 Introduction
3 Abbreviations
4 Component values
6 Ordering
7 Components
7 Unit AA01 : 6-wire measurement kit
8 Unit AM22 : 6-wire extension board
9 Unit AM16D : 6-wire test board

INTRODUCTION

1. Each sub-assembly or printed circuit board in this equipment has been allocated a reference designator code, e.g. A0, A1, A2 etc.

2. The complete component reference includes its reference designator as a prefix e.g. AM22C1 (capacitor C1 on the AM22 board) but for convenience in the text and diagrams the prefix is omitted unless it is needed to avoid confusion. However when ordering replacements or in correspondence the complete component reference must be quoted.

ABBREVIATIONS

3. Electrical components are listed in alpha-numerical order of their complete circuit reference and the following standard abbreviations are used in the "Description" column:

ADC	analogue-digital converter
AMP	amplifier
AX	axial
BUFF	buffer
CAP	capacitor
CER	ceramic
CERM	cermet
CON PCB	p.c.b. connector
DEC/DMX	decoder/demultiplexer
DECOD	decoder
DI	diode
FEM	female
FF D	D type flip-flop

INV	inverter
JUNC	junction
L BIAS	low bias current
MF	metal film
MIN	miniature
MO	metal oxide
MOD	module/modular
MONO	monostable
OCT	octal
PETP	polyester (polyethylene terephthalate)
PS	polystyrene
PSI	PNP silicon
Q/ACT	quick acting
RAD	radial
RES	resistor
RETR	retriggerable
RV	variable resistor
S/C ACC	semiconductor accessory
SCH	Schottky
SCHM	Schmitt
SUBMIN	Subminiature
TR	transistor trigger

COMPONENT VALUES

4. One or more of the components fitted in the equipment may differ from those listed in this chapter for any of the following reasons:

(a) Components indicated by an asterisk (*) have their values selected during test to achieve particular performance limits.

(b) Owing to supply difficulties, components of different value or type may be substituted provided the overall performance of the equipment is maintained.

(c) As part of a policy of continuous development, components may be changed in value or type to obtain detailed improvements in performance.

5. When there is a difference between the component fitted and the one listed, always use as a replacement the same type and value as found in the equipment.

ORDERING

6. When ordering replacements, address the order to our Head Office (address at rear of manual) or nearest agent and specify the following for each component required:-

(1) Type# of equipment.

(2) Complete circuit reference.

(3) Description.

(4) Part number.

#As given on the label at the rear of the equipment.

COMPONENTS

Circuit Ref	Description	Part Number
Unit AA01	- 6-WIRE MEASUREMENT KIT	
7.	When ordering, prefix circuit reference with AA01	
	Complete unit	51968-900
AM22	6-WIRE EXTENSION BOARD	44828969
AZ1	CABLE 6-WIRE MEASUREMENT	43130-190Y
AZ2	CABLE 6-WIRE ADAPTER	43130-205D
AZ3	CABLE ASSY C0 & C1 M/B LINK (2 OFF)	43129-821F
AZ4	SELF CHECK MOD KIT	46883-828Y
Unit AM22	- 6 WIRE EXTENSION BOARD	
8.	When ordering, prefix circuit reference with AM22	
	Complete unit	44828-969
C1	CAP ELEC 10U 35V 20% SUBMIN	26421-112Z
C2	CAP ELEC 22U 25V 20% SUBMIN	26421-114E
C3	CAP ELEC 4U7 35V 20% SUBMIN	26421-108A
C4	CAP ELEC 4U7 35V 20% SUBMIN	26421-108A
C5	CAP PETP 68N 100V 10% RAD	26582-224J
C6	CAP PETP 68N 100V 10% RAD	26582-224J
C7	CAP CER 1N5 63V 10% PLATE	26383-593A
C8	CAP ELEC 22U 25V 20% SUBMIN	26421-114E
C9	CAP PETP 1U0 50V 10% RAD MIN	26582-432F
C10	CAP PETP 1U0 50V 10% RAD MIN	26582-432F
C11	CAP PETP 1U0 50V 10% RAD MIN	26582-432F
C12	CAP PS 1N0 63V 1% RAD	26538-902G
C13	CAP CER 22P 63V 5% PLATE	26343-469N
C14	CAP CER 22P 63V 5% PLATE	26343-469N
C15	CAP CER 1N5 63V 10% PLATE	26383-593A
C16	CAP PETP 33N 63V 10% RAD MIN	26582-435S
C17	CAP PETP 100N 63V 10% RAD MIN	26582-429F
C18	CAP PETP 100N 63V 10% RAD MIN	26582-429F
C20	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C21	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C22	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C23	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C24	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C25	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C26	CAP CER 10N 50V 20% X7R MON AX	26346-120Y

Circuit Ref	Description	Part Number
Unit AM22	- 6 WIRE EXTENSION BOARD (continued)	
C27	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C28	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C29	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C30	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C31	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C32	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C33	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C34	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C35	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C36	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C37	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C38	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C39	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C40	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C41	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C42	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C43	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C44	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C45	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C46	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C47	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C48	CAP CER 10N 50V 20% X7R MON AX	26346-120Y
C49	CAP CER 3N9 63V 10% PLATE	26383-590R
C50	CAP CER 4N7 63V 10% PLATE	26383-591B
D1	DI SIL 1N4148 75V JUNC	28336-676J
D2	DI SIL 1N4148 75V JUNC	28336-676J
D3	DI SIL 1N4148 75V JUNC	28336-676J
D4	DI SIL 1N4148 75V JUNC	28336-676J
D5	DI SIL 1N4148 75V JUNC	28336-676J
D6	DI SIL 1N4148 75V JUNC	28336-676J
D10	DI SIL 1N4148 75V JUNC	28336-676J
D11	DI SIL 1N4148 75V JUNC	28336-676J
D12	DI SIL 1N4148 75V JUNC	28336-676J
D13	DI SIL 1N4148 75V JUNC	28336-676J
D14	DI SIL 1N4148 75V JUNC	28336-676J
D15	DI SIL 1N4148 75V JUNC	28336-676J
D16	DI SIL 1N4148 75V JUNC	28336-676J
D17	DI SIL 1N4148 75V JUNC	28336-676J
D18	DI SIL 1N4148 75V JUNC	28336-676J
D19	DI SIL 1N4148 75V JUNC	28336-676J
D20	DI SIL 1N4148 75V JUNC	28336-676J
D21	DI SIL 1N4148 75V JUNC	28336-676J
D22	DI SIL 1N4148 75V JUNC	28336-676J
D23	DI SIL 1N4148 75V JUNC	28336-676J

Circuit Ref	Description	Part Number
Unit AM22	- 6 WIRE EXTENSION BOARD (continued)	
D24	DI SIL 1N4148 75V JUNC	28336-676J
D25	DI SIL 1N4148 75V JUNC	28336-676J
D26	DI SIL 1N4148 75V JUNC	28336-676J
D27	DI SIL 1N4148 75V JUNC	28336-676J
D28	DI SIL 1N4148 75V JUNC	28336-676J
D29	DI SIL 1N4148 75V JUNC	28336-676J
D30	DI SIL 1N4148 75V JUNC	28336-676J
D31	DI SIL 1N4148 75V JUNC	28336-676J
D32	DI SIL 1N4148 75V JUNC	28336-676J
D33	DI SIL 1N4148 75V JUNC	28336-676J
D34	DI SIL 1N4148 75V JUNC	28336-676J
D35	DI SIL 1N4148 75V JUNC	28336-676J
D36	DI SIL 1N4148 75V JUNC	28336-676J
D37	DI SIL 1N4148 75V JUNC	28336-676J
D38	DI SIL 1N4148 75V JUNC	28336-676J
D39	DI SIL 1N4148 75V JUNC	28336-676J
D40	DI SIL 1N4148 75V JUNC	28336-676J
D41	DI SIL 1N4148 75V JUNC	28336-676J
D42	DI SIL 1N4148 75V JUNC	28336-676J
D43	DI SIL 1N4148 75V JUNC	28336-676J
D44	DI SIL 1N4148 75V JUNC	28336-676J
D45	DI SIL 1N4148 75V JUNC	28336-676J
D46	DI SIL 1N4148 75V JUNC	28336-676J
D47	DI SIL 1N4148 75V JUNC	28336-676J
D48	DI SIL 1N4148 75V JUNC	28336-676J
D49	DI SIL 1N4148 75V JUNC	28336-676J
D50	DI SIL 1N4148 75V JUNC	28336-676J
D51	DI SIL 1N4148 75V JUNC	28336-676J
D52	DI SIL 1N4148 75V JUNC	28336-676J
D53	DI SIL 1N4148 75V JUNC	28336-676J
D54	DI SIL 1N4148 75V JUNC	28336-676J
D55	DI SIL 1N4148 75V JUNC	28336-676J
D56	DI ZEN BZX79C3V0 3.0V 5%	28371-209P
D57	DI ZEN BZX79C5V1 5.1V 5%	28371-401U
D60	DI SIL 1N4148 75V JUNC	28336-676J
D61	DI SIL 1N4148 75V JUNC	28336-676J
D62	DI SIL 1N4148 75V JUNC	28336-676J
D63	DI SIL 1N4148 75V JUNC	28336-676J
D64	DI SIL 1N4148 75V JUNC	28336-676J
FS1	FUSE Q/ACT .75A 7.1X2.4 W/END	23411-861E
FS2	FUSE Q/ACT 3.5A 7.1X2.4 W/END	23411-863Y
IC1	ICD MONO 74LS123 DUAL RETR	28468-309B
IC2	ICD DEC/DMX 74LS138 3-8	28465-027F

Circuit Ref	Description	Part Number
Unit AM22	- 6 WIRE EXTENSION BOARD (continued)	
IC3	ICD DEC/DMX 74LS138 3-8	28465-027F
IC4	ICD NAND 74LS132 QUAD 2INP SCH	28469-205N
IC5	ICD NOR 74LS02 QUAD 2INP	28466-214Y
IC6	ICD OR 74LS32 QUAD 2INP	28466-108U
IC7	ICD DECOD 74LS42 4-10	28465-019U
IC8	ICD DECOD 74LS42 4-10	28465-019U
IC9	ICD DRIV 75453 DUAL PERI OR	28469-388X
IC10	ICD DRIV 75453 DUAL PERI OR	28469-388X
IC11	ICD DRIV 75453 DUAL PERI OR	28469-388X
IC12	ICD AND 74LS08 QUAD 2INP	28466-012L
IC13	ICD BUFF 7406 HEX O/C INV 30V	28469-158A
IC14	ICD BUFF 7406 HEX O/C INV 30V	28469-158A
IC15	ICD BUFF 7406 HEX O/C INV 30V	28469-158A
IC16	ICD BUFF 7406 HEX O/C INV 30V	28469-158A
IC17	ICD INV 74LS14 HEX SCHM	28469-176S
IC18	ICD INV 74LS14 HEX SCHM	28469-176S
IC19	ICD INV 74LS14 HEX SCHM	28469-176S
IC20	ICD INV 74LS14 HEX SCHM	28469-176S
IC21	ICD FF D 74LS273 OCT +EDG TR	28462-615U
IC22	ICD FF D 74LS174 HEX +EDG TR	28462-612Z
IC23	ICD FF D 74LS174 HEX +EDG TR	28462-612Z
IC24	ICD FF D 74LS174 HEX +EDG TR	28462-612Z
IC25	ICD FF D 74LS174 HEX +EDG TR	28462-612Z
IC26	ICD DRIV 75453 DUAL PERI OR	28469-388X
IC27	ICD DRIV 75453 DUAL PERI OR	28469-388X
IC28	ICD DRIV 75453 DUAL PERI OR	28469-388X
IC29	ICD DRIV 75453 DUAL PERI OR	28469-388X
IC30	ICA AMP 3527CM L BIAS TO99	28461-338X
IC31	ICA AMP TL071CP FET I/P DIL8	28461-347A
IC32	ICA AMP NE5534AN H-PRF DIL8	28461-358J
IC33	ICA AMP NE5534AN H-PRF DIL8	28461-358J
IC34	ICA MISC AD636KH RMS/DC CONVTR	28461-941Y
IC35	ICD NAND 74LS00 QUAD 2INP	28466-345H
LP1	LAMP LED CQY40L 3V RED	28624-104W
LP2	LAMP LED CQY40L 3V RED	28624-104W
MP5	CON PCB FEM 1 FXD 1.02/5.08	23421-084D
MP8	S/C ACC PAD TO5 TO DIL10	28488-101C
MP9	S/C ACC PAD TO5,ETC TO 0.1"GRD	28488-113Y
R1	RES MO 1K0 1/2W 2% 250PPM	24573-073W
R2	RES MO 1K3 1/2W 2% 250PPM	24573-076P
R3	RES MF 1K0 1/4W 2% 100PPM	24773-273A
R4	RES MF 180R 1/4W 2% 100PPM	24773-255V
R5	RES MF 180R 1/4W 2% 100PPM	24773-255V

Circuit Ref	Description	Part Number
Unit AM22	- 6 WIRE EXTENSION BOARD (continued)	
R6	RES MF 1KO 1/4W 2% 100PPM	24773-273A
R7	RES MF 6K8 1/4W 2% 100PPM	24773-293D
R8	RES MF 2K7 1/4W 2% 100PPM	24773-283L
R9	RES MF 100K 1/4W 2% 100PPM	24773-321L
R10	RES MF 100K 1/4W 2% 100PPM	24773-321L
R11	RES MF 6K8 1/4W 2% 100PPM	24773-293D
R12	RES MF 1KO 1/4W 2% 100PPM	24773-273A
R13	RES MF 330R 1/4W 2% 100PPM	24773-261D
R14	RES MF 4K7 1/4W 2% 100PPM	24773-289W
R15	RES MF 100K 1/4W 2% 100PPM	24773-321L
R16	RES MO 1K3 1/2W 2% 250PPM	24573-076P
R17	RES MF 910R 1/4W 2% 100PPM	24773-272K
R20	RES MF 2KO 1/4W 2% 100PPM	24773-280U
R21	RES MF 1K6 1/4W 2% 100PPM	24773-278Y
R22	RES MF 20KO 1/4W 0.5% 50PPM	24753-663N
R23	RES MF 10KO 1/4W .1% 50PPM	24723-405W
R24	RES MF 10KO 1/4W .1% 50PPM	24723-405W
R25	RES MF 5KO 1/4W .1% 50PPM	24723-401F
R26	RV CERM 5K LIN .3W 10% FLAT	25748-506P
R27	RES MF 10KO 1/4W .1% 50PPM	24723-405W
R28	RES MF 10KO 1/4W .1% 50PPM	24723-405W
R29	RES MF 10KO 1/4W .1% 50PPM	24723-405W
R30	RV CERM 20K LIN .3W 10% FLAT	25748-508M
R40	RES MF 3K9 1/4W 2% 100PPM	24773-287V
R41	RES MF 12R 1/4W 2% 100PPM	24773-227T
R42	RES MF 220R 1/4W 2% 100PPM	24773-257W
R43	RES MF 1KO 1/4W 2% 100PPM	24773-273A
R44	RES MF 6K8 1/4W 2% 100PPM	24773-293D
R45	RES MF 1KO 1/4W 2% 100PPM	24773-273A
R47	RV CERM 100K LIN .3W 10% FLAT	25748-510X
R48	RV CERM 100K LIN .3W 10% FLAT	25748-510X
RLA	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLB	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLC	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLD	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLE	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLF	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLG	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLH	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLJ	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLK	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLL	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLM	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R

Circuit Ref	Description	Part Number
Unit AM22	- 6 WIRE EXTENSION BOARD (continued)	
RLN	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLP	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLR	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLS	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLT	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLU	RELAY MAG 1CO 12V 890R	23486-104S
RLV	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLW	RELAY REED 4NO 24V 4.7K LO EMF	23486-527B
RLX	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLY	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLZ	RELAY REED 4NO 24V 4.7K LO EMF	23486-527B
RLZA	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
RLZB	RELAY REED 1NO 24V 6.0K LO EMF	23486-526R
TR1	TR PSI 2N2905A 60V 200M - GEN	28435-868C
TR2	TR PSI BC307A 45V 130M - GEN	28435-227H
TR3	TR PSI BC307A 45V 130M - GEN	28435-227H
TR4	TR PSI BC307A 45V 130M - GEN	28435-227H
TR5	TR PSI 2N2905A 60V 200M - GEN	28435-868C
X1	MOD PSU 940 5V TO +/-15V CNV	28541-013F
Unit AM16D	- 6-WIRE TEST BOARD	
9.	When ordering, prefix circuit reference with AM16D	
	Complete unit	44829-310S
D1	DI SIL 1N4148 75V JUNC	28336-676J
D2	DI SIL 1N4148 75V JUNC	28336-676J
D3	DI SIL 1N4148 75V JUNC	28336-676J
D4	DI SIL 1N4148 75V JUNC	28336-676J
D5	DI SIL 1N4148 75V JUNC	28336-676J
D6	DI SIL 1N4148 75V JUNC	28336-676J
R1	RES MF 5R1 1/4W 2% 100PPM	24773-218F
R2	RES MF 5R1 1/4W 2% 100PPM	24773-218F
R3	RES MF 5R1 1/4W 2% 100PPM	24773-218F
R4	RES MF 5R1 1/4W 2% 100PPM	24773-218F
R5	RES MF 12R 1/4W 2% 100PPM	24773-227T
R6	RES MF 100R 1/4W 2% 100PPM	24773-249J
R7	RES MF 100R 1/4W 2% 100PPM	24773-249J
R8	RES MF 100R 1/4W 2% 100PPM	24773-249J
R9	RES MF 100R 1/4W 2% 100PPM	24773-249J
R10	RES MF 100R 1/4W 2% 100PPM	24773-249J

Circuit Ref	Description	Part Number
Unit AM16D	- 6-WIRE TEST BOARD (continued)	
R11	RES MF 100R 1/4W 2% 100PPM	24773-249J
R13	RES MF 1R0 1/4W 2% 100PPM	24773-201M
R14	RES MF 5R1 1/4W 2% 100PPM	24773-218F
R15	RES MF 20R 1/4W 2% 100PPM	24773-232X
R16	RES MF 82R 1/4W 2% 100PPM	24773-247N
R17	RES MF 330R 1/4W 2% 100PPM	24773-261D
R18	RES MF 1K3 1/4W 2% 100PPM	24773-276E
R19	RES MF 5K1 1/4W 2% 100PPM	24773-290V
R20	RES MF 22K 1/4W 2% 100PPM	24773-305R
R21	RES MF 82K 1/4W 2% 100PPM	24773-319J
R22	RES MF 330K 1/4W 2% 100PPM	24773-333P
RLA	RELAY REED 4NO 24V 4.7K LO EMF	23486-527B
RLB	RELAY REED 4NO 24V 4.7K LO EMF	23486-527B
RLC	RELAY REED 4NO 24V 4.7K LO EMF	23486-527B
RLD	RELAY REED 4NO 24V 4.7K LO EMF	23486-527B
RLE	RELAY REED 4NO 24V 4.7K LO EMF	23486-527B
RLF	RELAY REED 4NO 24V 4.7K LO EMF	23486-527B
RLG	RELAY REED 1NO 24V 1K6	23486-514V
UT1	INDUCTOR, 5.5uH	44290-925H
UT2	INDUCTOR,12uH	44290-926E
UT3	INDUCTOR, 30uH	44290-927U
X1	TERM C/PIN 0.64SQX6 S/E REEL	23435-188V

Chapter 7

SERVICING DIAGRAMS

CONTENTS

Para.
1 Circuit notes

Fig. Page
1 6-wire measurement cable 2
2 AM22 Circuit diagram, Sheet 1 ... ... 3/4
3 AM22 Circuit diagram, Sheet 2 ... ... 5/6
4 AM16D Circuit diagram 7/8

CIRCUIT NOTES

1. On the circuit diagrams the letter in the component value code replaces the decimal point and indicates the multiplier and unit as follows:-

Resistors : Code letter R = ohms, k = kilohms (10^3), M = megohms (10^6).

Capacitors : Code letter m = millifarads (10^{-3}), U = microfarads (10^{-6}), n = nanofarads (10^{-9}), p = picofarads (10^{-12}).

Inductors : Code letter H = henrys, m = millihenrys (10^{-3}), U = microhenrys) (10^{-6}).

SIC : Value selected during test, nominal value shown.

Components are marked normally with two, three or four figures according to the accuracy limit ±10%, ±1% or ±0.1%. Because a marking 4m7 could be interpreted as 4.7 milliohms, millifarads or millihenrys each value is placed near to its related symbol.

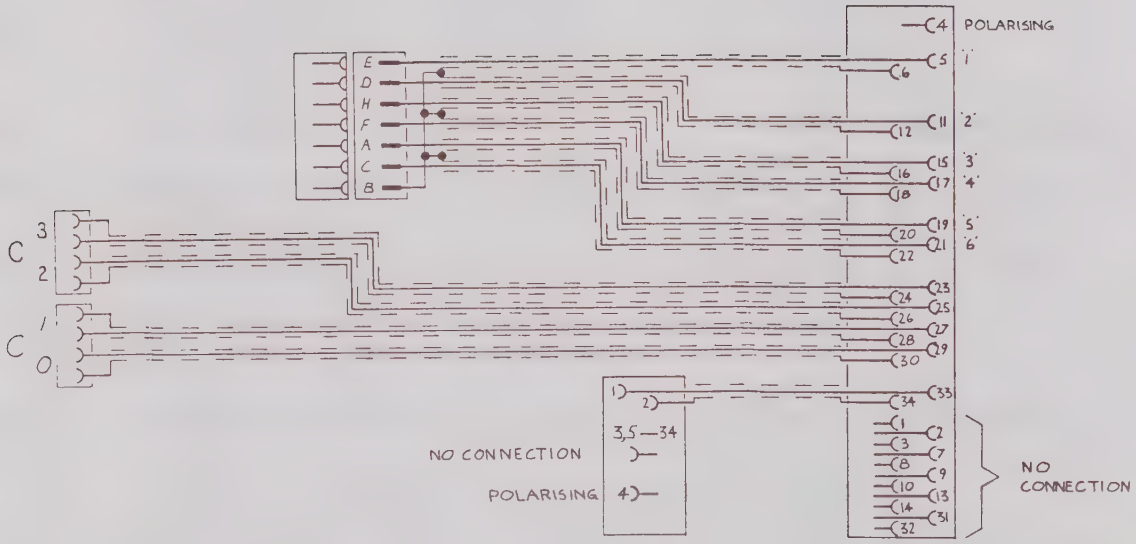
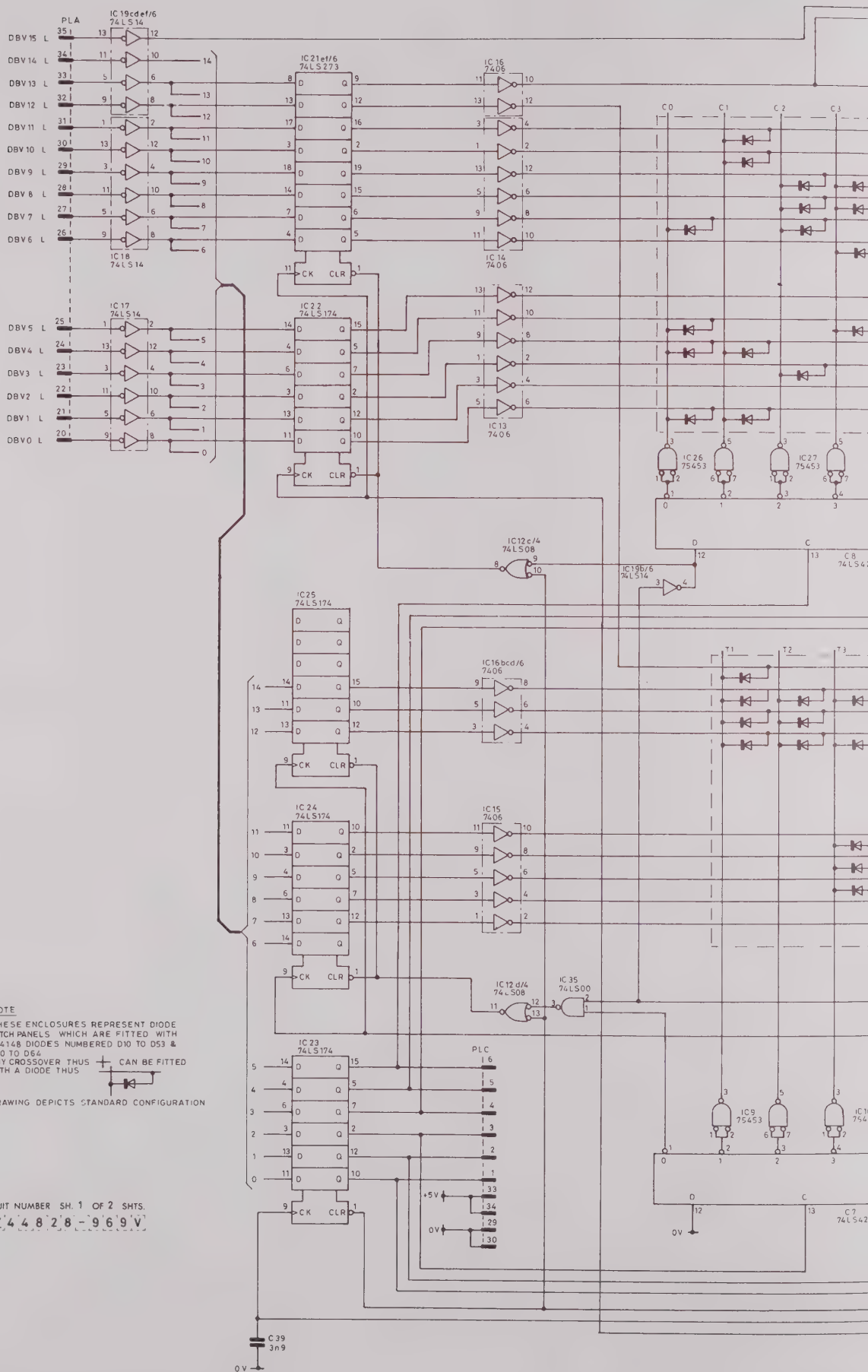


Fig. 1 6-wire measurement cable



NOTE

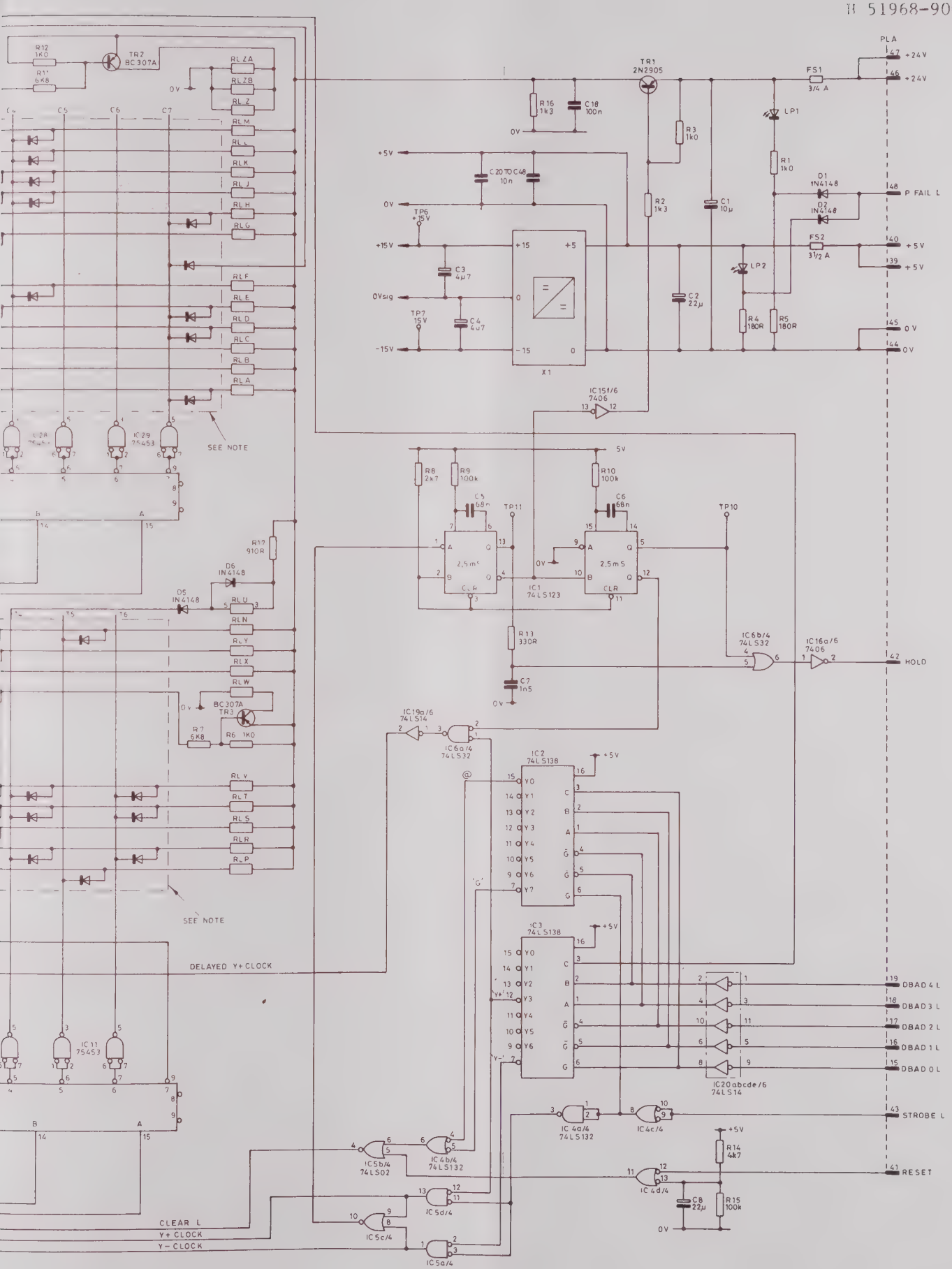
THESE ENCLOSURES REPRESENT DIODE PATCH PANELS WHICH ARE FITTED WITH IN4148 DIODES NUMBERED D10 TO D53 & D60 TO D64.
ANY CROSSOVER THUS + CAN BE FITTED WITH A DIODE THUS

DRAWING DEPICTS STANDARD CONFIGURATION

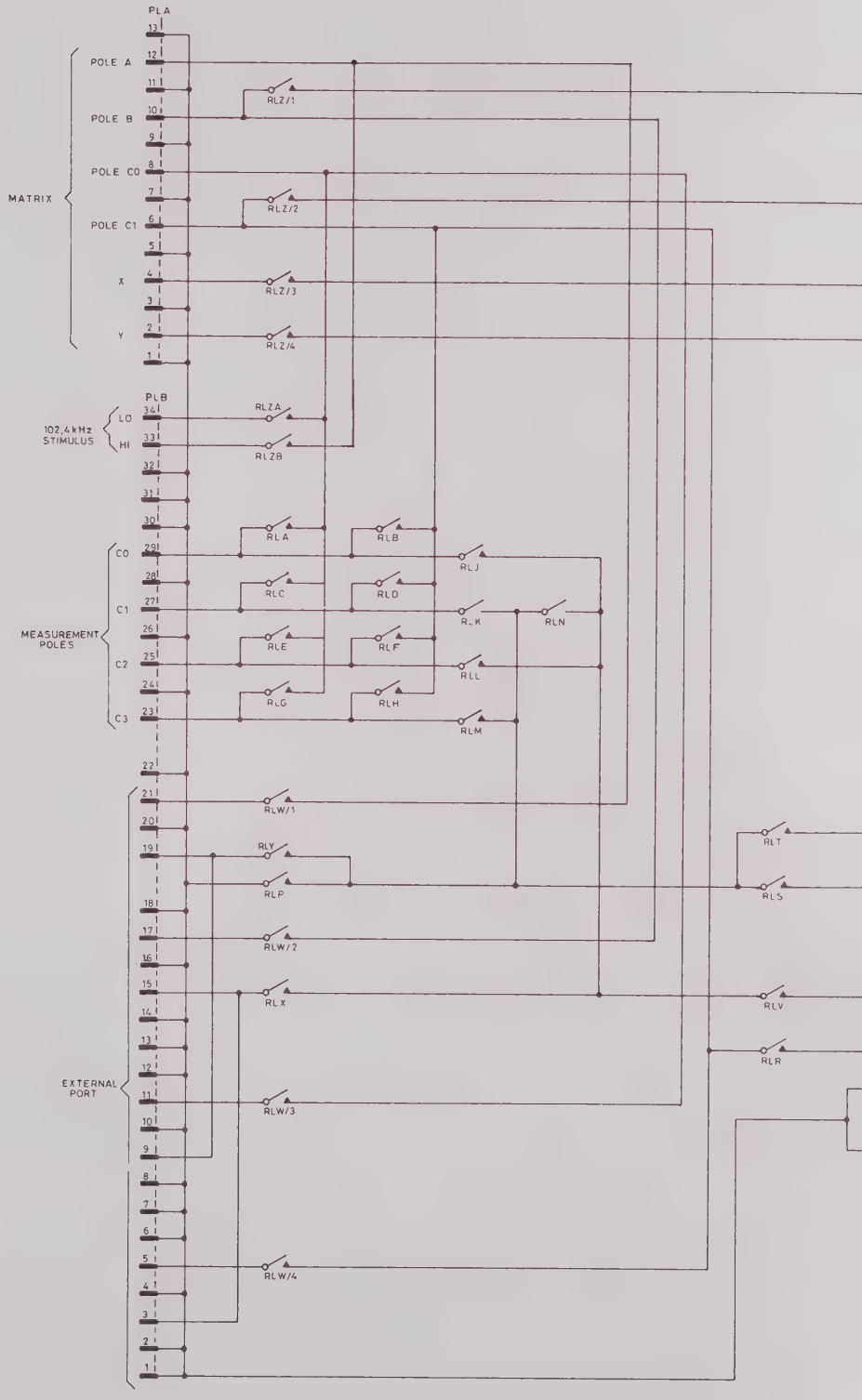
CIRCUIT NUMBER SH. 1 OF 2 SHTS.
Z 4 4 8 2 8 - 9 6 9 V

Fig. 2

Jan. 86 (Am. 2)



22 Circuit diagram, Sheet 1

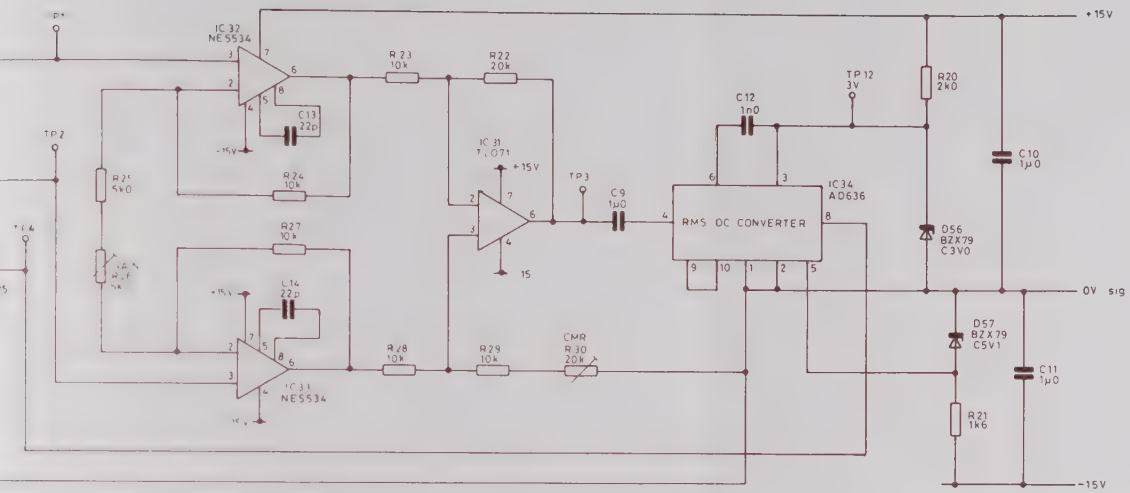


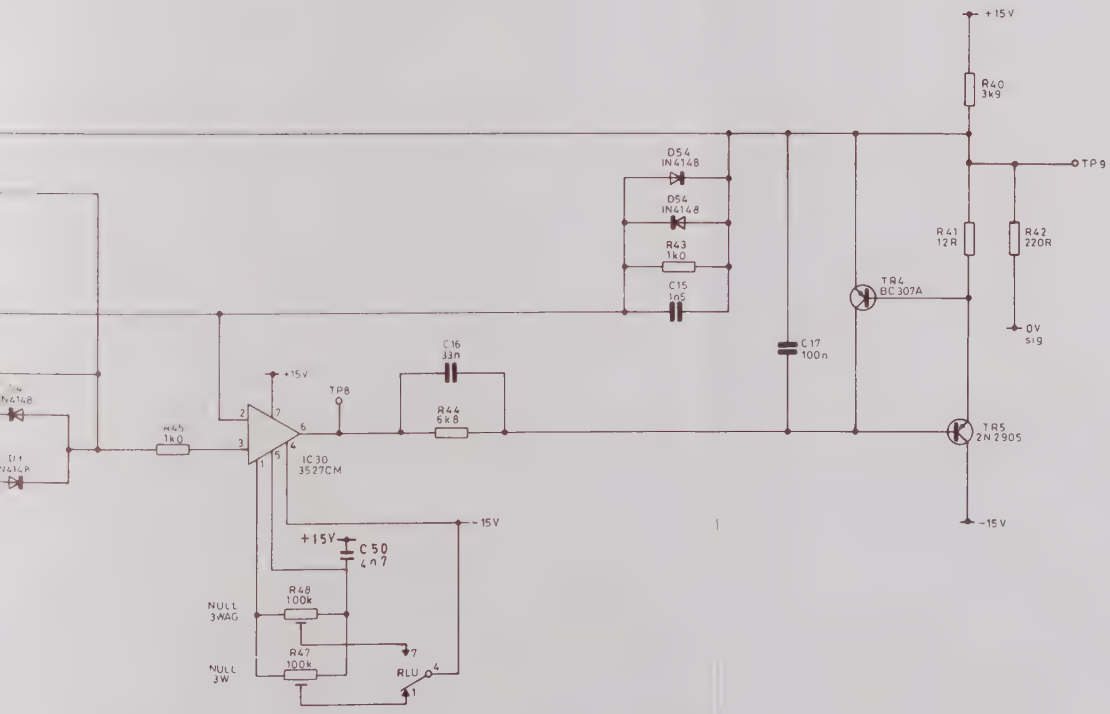
CIRCUIT NUMBER SH. 2 OF 2 SHTS.
Z44828-9691V

Fig. 3

Jan. 86 (Am. 2)

Fig. 3 AM22 Circuit di


IC32
NE5534
R23
10k
R22
20k
C13
22p
R24
10k
IC31
TL071
+15V
TP3
C9
1µ0
C12
1n0
TP12
3V
R20
2k0
C10
1µ0
IC34
AD636
RMS DC CONVERTER
D56
BZX79
C3V0
0V sig
R27
10k
C14
22p
R28
10k
R29
10k
CMR
R30
20k
IC33
NE5534
D57
BZX79
C5V1
C11
1µ0
R21
1k6
-15V


+15V
R40
3k9
TP9
D54
IN4148
D54
IN4148
R43
1k0
C15
1n5
R41
12R
R42
220R
TR4
BC307A
0V
sig
C16
33n
C17
100n
TP8
R44
5k8
TR5
2N2905
IC30
3527CM
-15V
+15V
C50
4n7
R48
100k
NULL
3MAG
R47
100k
NULL
3W
RLU

gram, Sheet 2

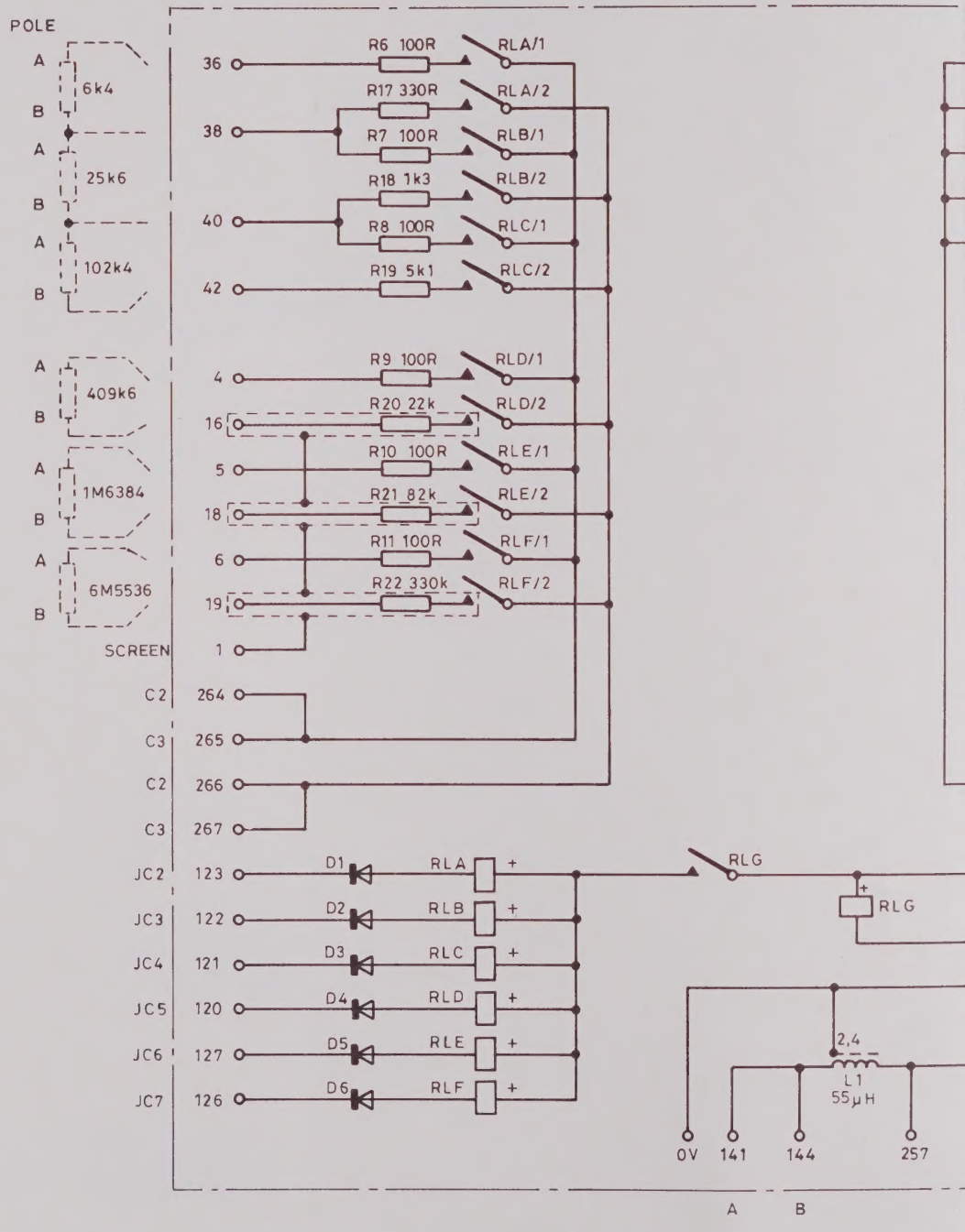


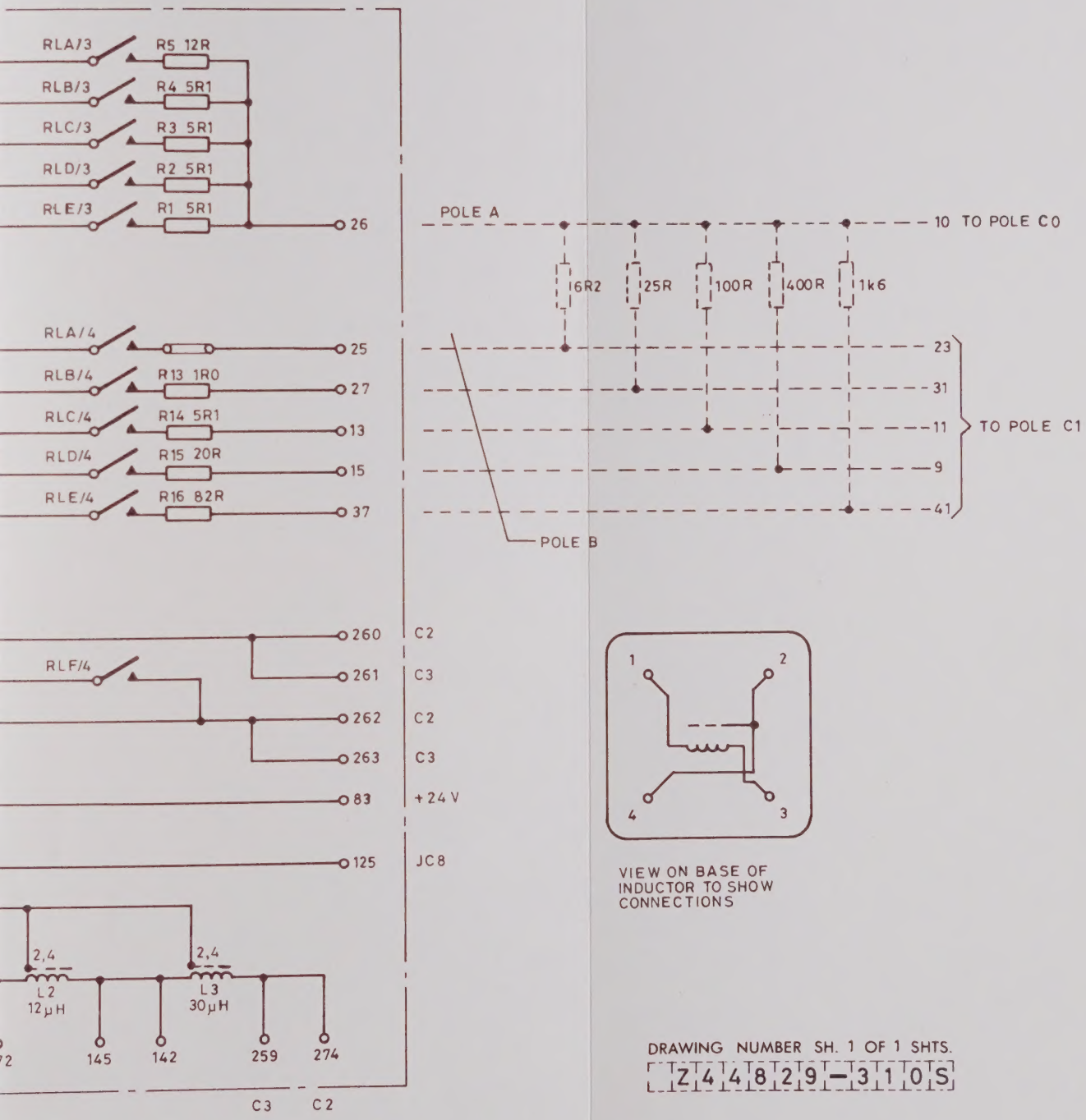
Fig. 4

AM16D

Jan. 86 (Am. 2)

NOTES

1. DOTTED COMPONENTS ARE ON AM16 & ARE SHOWN FOR REF. ONLY.



VIEW ON BASE OF INDUCTOR TO SHOW CONNECTIONS

DRAWING NUMBER SH. 1 OF 1 SHTS.

Z448 29-310S

ircuit diagram

1968

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